PAPERGPT

ASRB EXAM 2026

ELECTRONICS & INSTRUMENTATION

NET, ARS, SMS (T-6) & STO (T-6)

CHAPTERWISE 25 YEARS PYQ

- 3000+ MCQs with Full Explanation
- As per syllabus released by Agricultural Scientists Recruitment Borad

NODIA

PAPERGPT

Scan QR for Demo PDF

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

ASRB 2026

AGRICULTURAL SCIENTISTS RECRUITMENT BOARD

NET, ARS, SMS (T-6) & STO (T-6)

ELECTRONICS & INSTRUMENTATION

Chapter-Wise Previous 25 Years PYQ Bank

PAPERGPT

Downloaded from www.pdf.tube

ASRB ELECTRONICS & INSTRUMENTATION
Edition: July 2026
Copyright © By PAPERGPT

Information contained in this book has been obtained by author, from sources believes to be reliable. However, neither PAPERGPT nor its author guarantee the accuracy or completeness of any information herein, and PAPERGPT nor its author shall be responsible for any error, omissions, or damages arising out of use of this information. This book is published with the understanding that PAPERGPT and its author are supplying information but are not attempting to render engineering or other professional services.

MRP Rs 650.00

Published by :
PAPERGPT
125, Sector 6, Vidyadhar Nagar, Jaipur 302039
Phone :+91 9001005245

CONTENTS

CHAP : 01	Transducers and Applications	9
CHAP : 02	Signal Conditioning Circuits	66
CHAP : 03	Process Control Instrumentation	125
CHAP : 04	Data Acquisition Systems	185
CHAP : 05	Virtual Instrumentation	241
CHAP : 06	Analytical Instrumentation	299
CHAP : 07	Real Time and Embedded Systems	357
CHAP : 08	Digital Image Processing	416
CHAP : 09	Microcontroller, PLC, SCADA Programming and Their Applications	471
CHAP : 10	Robot Design and Control	529
CHAP : 11	Speech Processing	585

****

Click Here to Buy book on Amazon

59. ELECTRONICS & INSTRUMENTATION

Unit-1: Transducers and Applications

Introduction to Measurement Systems: General concepts and terminology, measurement systems, sensor classification, static characteristics of measurement systems-Range, accuracy, linearity, resolution, noise, repeatability, precision and sensitivity etc. Estimation of errors. Dynamic characteristics of measurement systems. Zero-order first-order and second-order measurement systems and response. Measuring Devices: Displacement: Resistive Potentiometer, Resistive strain gauges inductive displacement transducer, CapacitiveDisplacement Transducers, Piezo Electric Transducers, Ultrasonic Methods. Temperature: Thermal expansion methods, Thermo electric, radiation methods-thermal and photon detectors based thermometers. Pressure: Methods of pressure measurement: Dead weight gauges and manometers, elastic transducers, high pressure measurement. Flow: Anemometers, velocity sensors obstruction meters, averaging Pitot tubes, Rota meters, Electromagnetic, Vortex shedding, Ultrasonic Flow meters. Velocity and Acceleration: Seismic displacement, velocity and acceleration pickups (Accelerometers). Gyroscopic angular displacement and velocity sensors. Force and Torque: Methods of force measurement and characteristics, Bonded strain gauge, Variable Reluctance, Piezo Electric Transducer, Torque measuring on rotating shafts. Humidity, Density and Radiation Measurement: Capacitive Impedance and Piezoelectric Hygrometers. Differential Pressure, U-tube and ultrasonic Densitometers and pH measurement: Ion Selective Type. Radiation Fundamentals-Radiation Detectors - Radiation Thermometers and Optical Pyrometers. Digital Sensors: Position encodes, variable frequency sensors-quartz digital thermometer, SAW sensors, digital flow meters, sensors based on semiconductor junctions: thermometers based on semiconductor junctions, magneto diodes and magneto transistors, photodiodes andphototransistors, charge-coupled sensors.

Unit-2: Signal Conditioning Circuits

Bridges: The Wheat Stone Bridge - Single Variable Element, Two Single Variable Element& Four Single Variable Element, Excitation, Readout - bridge amplifier, instrumentation Amplifier, minimize common mode voltage, Isolator, Chopper Amplifier Interference: Local Problems, Subsystems Problems - grounding mechanisms, Outside & Local Interface - guard circuit, Analog Filtering - Design of 1st order & 2nd order filters, Operational Amplifiers, Instrumentation Amplifiers, Isolation Amplifiers, System Solutions Offsetting & Linearizing:Offsetting - use of bridge in offsetting, 4 - to - 20 mA Current Transmission - typical 4 - 20 mA Transmission, isolated 4 - 20 mA Transmission, basic 0 to 10 V to 4 to 20 mA Translation circuit, Non Linearity & Linearizing - Digital Linearizing & Analog Linearizing Thermoswitches & Thermocouples Interfacing: Thermo switches, Ambient Referenced Thermocouples, Isolated Thermocouple Measurement, Thermocouple to Frequency, Thermocouple to 4 - to - 20 m A Temperature Transmitter, Isolated Multiplexing of Thermocouples RTD's Interfacing: Single Op - Amp Interface, using a Signal Conditioner, Bridge configuration using 3 -wire RTD, Linearizing RTD Circuits, Current Transmitters for RTD Outputs, RTD Based Precision controller Thermistor Interfacing: Simple InterfaceCircuits, High - Resolution Differential Thermometer, Current Transmitters, Thermistor to Frequency Conversion Semiconductor Temperature Transducers Interfacing: T - to - F Conversion using Diodes, Absolute Temperature - to - current Conversion, Temperature Control Circuits, Multiplexed Applications, Isolation, 4 - to - 20 m A Current Transmission Pressure Transducer Interfacing: Strain Gauge Based Transducers, Potentiometer toFrequency Transducer, Interfacing High level Semiconductor Transducers, Isolated Pressure Transmitter, Pressure Control System. Force Transducer Interfacing: Spring Driven Rheostat, Strain - gauge & Signal Conditioner, High Resolution Load Cell Platform Interface, Strain Gauge to Frequency Conversion, Isolators & Transmitters Flow Meter Interfacing: Differential Pressure Flow meters, Frequency output Flowmeters, Anemometers, Hinged Vane Flowmeter, Thermal Flow Meter, Transmission & Readout Level Transducers Interfacing: Float & Potentiometer, Optical Sensing & Thermal Sensing Miscellaneous Applications: 4 - to - 20 m A Transmission, Topics on Filtering, Programmable - Gain Isolator, High - Performance Floating Data Amplifier, Isolated All - Electronic Multiplexing, Pulsed - Mode Bridge Excitation

Unit-3: Process Control Instrumentation

Introduction: Incentives for process control, Design aspects of process control system, Process degree of freedom. Mathematical model of first order processes: level, pressure and thermal processes - Second order process: Interacting and non-interacting processes, - Time and frequency response analysis. Basic Single Loop Control Actions: Characteristics and dynamics of Discrete

NODIA

Control Modes: ON-OFF, Multi Speed, Floating Controllers. Characteristics and dynamics offeedback control modes: Proportional, Integral and Derivative control modes - P+I, P+D and P+I+D control modes. P-1-D Controller Tuning and Stability Analysis: Tuning of Controllers: Evaluation criteria - IAE, ISE, ITAE, Tunings - Process reaction curve method - Ziegler Nichols method - Damped oscillation method.Design of Lead, Lag compensators, stability analysis MIMO Systems -Multi-loop Control: MIMO Systems: Dynamics of Distillation column and Heat exchangers processes, Multi loopControllers: Feed-forward control - ratio control- cascade control - adaptive - split-range control - multivariable control - examples from distillation column and boiler systems. Modem control practices in: Power plants, pharmaceuticals and petrochemicals industries. Final Control Element: /P converter - pneumatic and electric actuators - valve positioner - control valves -characteristics of control valves - inherent and installed characteristics -control valve sizing - cavitation and flashing -selection criteria.

Unit-4: Data Acquisition Systems

Data Loggers and Data Acquisition Systems: Data acquisition systems-configurations components, analog multiplexes and sample and hold circuits-specifications and design considerations. DACs: specifications - characteristics, types of DACs (serial, parallel, direct and indirect). Hybrid and monolithic DACs. ADCs: specifications - characteristics, types of ADCs (serial, parallel, direct and indirect). Hybrid and monolithic ADCs. sigma-delta ADCs',Hybrid DAS - Schematic diagram - configurations - specifications. Error Budget of DACs and ADCs: Error sources, error reduction and noise reduction techniques in DAS. Error budget analysis of DAS. Case study of a DAC and an ADC. Data Acquisition Hardware and Software: Specifications of Hardware-IO analog signal range, gain for analog input and resolution in ADC converter, resolute\ion in DAC and counter chips, sampling frequency andmaximum update rates, triggering capacity. Digital lines and ports, data acquisition VIs. Distributed AND Stand Alone Data Loggers: Introduction, methods of operation-programming and logging data using PCMCIA cards, standard alone operation- direct and remote connection to the host PC, standalone logger/controller hardware interface-RS232C, RS485 standard, communication bottlenecks and system performance, using Ethernet toconnect data loggers. IEEE 488 Standard: Introduction, characteristics, physical connection configurations, device types, bus structure, GPIB hand shake, device communication, IEEE 488.2, standard commands for programmable instruments. Display Systems: LCD Flat panel displays, Digital storage CROs, Plasma displays, Projection systems. Analyzers - Spectrum Analyzers - guidelines, various triggering techniques, different types of spectrum analyzers, Recorders. Display devices and Display systems, Logic Analyzers - State and time referenceddata capture. Scalar and Vector Network analyzers.

Unit-5: Virtual Instrumentation

Virtual Instrumentation: Historical perspective, advantages, block diagram and architecture of a virtual instrument, data-flow techniques, graphical programming in data flow, comparison with conventional programming. Development of Virtual Instrument using GUI, Real-time systems, Embedded Controller, OPC, HMI / SCADA software, Active X programming. VI Programming Techniques: VIs and sub-VIs, loops and charts, arrays, clusters and graphs, case and sequence structures, formula nodes, local and global variables, string and file I/O, Instrument Drivers, Publishing measurement data in the web. VI Chassis Requirements: Common Instrument Interfaces: Current loop, RS 232C/ RS485, GPIB. VISA and IVI. Application of Virtual Instrumentation: Instrument Control, Signal Measurement and generation: Data Acquisition. Advanced LabVIEW Data Concepts: Advanced file I/O, Configuring INI files, Calling code from other languages, Fitting Square Pegs into round holes: Advanced. Connectivity in Lab VIEW: Lab VIEW web server, E-mailing data from Lab VIEW, Remote Panels, Self-describing data, shared variables, talking to other programs and objects, talking to other computers, database, report generation. Simulation of systems using VI, Development of Control system, Industrial Communication, Image acquisition and processing, Motion control.

Unit-6: Analytical Instrumentation

Electrochemical Instruments: Basic concepts of Analytical instrumentation, Electro chemical instruments- pH meter, Conductivity meter, Dissolved oxygen analyzers using Polarographic principle - sodium analyzer- silica analyzers- Polarographic Instruments. Absorption Spectrophotometers: UV, VIS spectrophotometers - single beam and double beam instruments - instrumentation associated with the above spectrophotometers - sources and detectors. IR SPM-sources and detectors for IR spectrophotometers, FTIR, Raman Spectroscopy, Interpretation & Analysis. Emission Spectrophotometers: Flame emission and atomic absorption spectrophotometer - Atomic emission spectrophotometer - sources for Flame Photometers and online calorific value

Downloaded from www.pdf.tube

measurements. Gas and LiquidChromatographs: Basic principle of gas chromatography, liquid chromatography, HPLC different types of columns, detectors, recorders and associated equipment, Salient features of liquid chromatography, Detectors used. Principle of Nuclear Magnetic Resonance: Instrumentation associated with NMR spectrophotometer- Introduction to mass spectrophotometers, Principle of electron spin resonance (ESR). Gas Analyzers: Flue gas analysis using thermal conductivity principle, Katharometer - oxygen analyzers using paramagnetic principle, Zirconium oxide cells, Pollution Monitoring Instruments. Industrial analyzer circuits; CO monitors - Nox analyzer - Sox Analyzer - H2S analyzer system,Nuclear Radiation Detectors: GM counter, Scintillation counter, Ionization chamber - Solid state detector, Gamma Spectrometry, Industrial application of radiation measurement. Thermal Analyzers: Differential Scanning Calorimetry (DSC), Derivative Thermo Gravimetric Analyzers (DTGA).

Unit-7: Real Time and Embedded Systems

Introduction: Embedded systems overview, design challenge, processor technology, IC technology, Design Technology, Trade-offs. Single purpose processors RT-levelcombinational logic, sequential logic (RT-level), custom single purpose processor design (RT-level), optimizing custom single purpose processors. General Purpose Processors and Communication Interface: Basic architecture, operation, Pipelining, Programmer's view,
development environment, Application Specific Instruction-Set Processors (ASIPs)- Micro Controllers and Digital Signal Processors. Need for communication interfaces, RS232
/UART, RS422 / RS485, USB, Infrared, IEEE 1394 Firewire, Ethernet, IEEE 802.11, Blue tooth. Introduction to RTOS and Basic Design: Architecture of the Kernel, Tasks and Task scheduler, Interrupt service routines, Semaphores, Mutex, Mailboxes, Message Queues, Event Registers, Pipes, Signals Principles, Semaphores and Queues, Hard real time scheduling considerations, Saving memory and power an example RTOS like µC - OS (Open Source) Embedded S/W Development tools. Real Time Operating Systems: Timers, Memory Management, Priority inversion problem, Embedded operating systems Embedded Linux, Real-time operating systems, RT Linux, Handheld operating systems, Windows CE. Design Technology: Introduction, Automation, Synthesis, Parallel evolution of compilation and synthesis, Logic Synthesis, RT synthesis, Behavioral Synthesis, Systems Synthesis and Hardware/ Software Co- Design, Verification, Hardware/Software co-simulation, Reuse property codes.

NODIA

Unit-8: Digital Image Processing

Introduction: Fundamentals steps of Image processing, Components of an Image processing system, Image sampling and quantization, relationship between the pixels. Gray level transformation, Smoothing and sharpening spatial filters, Smoothing and sharpening frequency domain lters, Homo morphic filtering. Image Transforms: 2-Dimensional Orthogonal and Unitary Transforms-I-Dimensional DFT-2-Dimensional DFT- CosineTransform- The Sine Transform- The Hadamard Transform- The Haar Transform- The Slant Transform -The KL Transform- The Singular Value Decomposition Transform. Image Enhancement: Basic Gray Level Transformations-Image Negatives, Log transformations, Power-law Transformations, Piecewise-Linear Transformation Functions- Histogram Processing-Histogram equalization, Histogram matching, local Enhancement, Use of Histogram Statistics for Image Enhancement-Enhancement using Arithmetic/Logic Operations-Image Subtraction, Image Averaging. Image Segmentation: Edge linking and boundary detection, Thresholding- Global and Adaptive, Region based segmentation, Segmentation by morphological watersheds, color segmentation. Colour Image Processing: Colour Fundamentals- Colour Models- Pseudocolour Image Processing- Basics of Full- Colour Image Processing - Colour Transformations- Smoothing and Sharpening - Colour Segmentation - Noise in Colour Images - Colour Image Compression Morphological Operations: Dilation and erosion, Opening and closing, Hit or Miss transforms, Morphological algorithms, Extensions to gray scales images and its applications. Imagecompression: Compression models, Error free coding, lossy coding, compression standards, color image compression, Introduction to fractals.
Image Representation and Description: Representation-Chain codes, Polygonal Approximations, Signatures, Boundary Segments, Skeletons- Boundary Descriptors- simple descriptors, shape numbers, Fourier Descriptors, statistical moments -Regional Descriptors- simple descriptors, topological descriptors, texture, moments of two- dimensional functions. Image Degradation/Restoration: Unconstrained and Constrained Restoration- Restoration in the presence of Noise Only-Spatial Filtering, Periodic Noise Reduction by Frequency Domain Filtering, Estimating the degradation Function-Estimation by Image Observation, Estimation by Experimentation, Estimation by Modeling- Inverse Filtering- Minimum Mean Square Error (Wiener)

Filtering- Constrained Least Squares Filtering- Geometric Mean Filter Geometric Transformations- Spatial transformations, Gray-level Interpolation.

Unit-9: Microcontroller, PLC, SCADA Programming and their Applications Microcontroller: Architecture, programming and applications, Programmable Logic Controller (PLC) Basics: Definition, Overview of PLC systems, input/output modules, Powersupplies and Isolators. Basic PLC programming: Programming On-Off inputs/ outputs.Creating Ladder diagrams, Basic PLC functions, PLC Basic Functions, register basics. PLC Intermediate and Advanced Functions: Arithmetic functions, Number comparison functions, Skip and MCR functions, data move systems. Utilizing digital bits, sequencer functions, Matrix fu ctions. PLC Advanced Functions: Analog PLC operation, Networking of PLC, Applications of PLC: Controlling of Robot using PLC, PID control of continuous processes etc. HART and Field Bus:

Introduction-Evolution of signal standard – HART Communication Protocol - Communication Modes - HART (Highway Addressable Remote Transducers) modes-Control system interface HART commands - HART Field Controller - Field Bus Architecture Basic requirement of field bus standard fieldbus topology, CAN bus." SCADA: Basic building blocks of computer control system - SCADA - MTU and RTU, Casestudies On SCADA.

Unit-10: Robot Design and Control

Robot Fundamentals: Definitions, History of robots, present and future trends in robotics, Robot classifications, Robot configurations, Point to Point robots, Continuous Path robots, Work volume, Issues in design and controlling robots Repeatability, Control resolution, spatial resolution, Precision, Accuracy, Robot configurations, Point to Point robots, Continuous Path robots, Work volume, Applications of robots. Drives used in robots- Hydraulic, Pneumatic and Electric drives, Comparison of drive systems and their relative merits and demerits. Manipulator Kinematics: Matrix Algebra, Inverse of matrices, rotational groups, matrix representations of coordinate transformation, transformation about reference frame and moving frame Forward & Inverse Kinematics examples of 2R, 3R & 3P manipulators, Specifying position and orientation of rigid bodies Euler's angle and fixed rotation for specifying position and orientation Homogeneous coordinate transformation and examples D-H representation of kinematics linkages Forward kinematics of 6R manipulators using D-H representations Inverse kinematics of 6R manipulators using D-H representations, Inverse Kinematics geometric and algebraic methods.

Robotics Dynamics: Velocity Kinematics, Acceleration of rigid body, mass distribution Newton's equation, Euler's equation, Iterative Newton -Euler's dynamic formulation, closed dynamic, Lagrangian formulation of manipulator dynamics, dynamic simulation, computational consideration. Autonomous navigation and Trajectory Planning: Introduction, general considerations in path description and generation, joint space schemes, Cartesian space schemes, path generation in runtime, planning path using dynamic model point to point and continuous trajectory, 4-3-4 & trapezoidal velocity strategy for robots. Robot Sensors: Internal and external sensors, position- potentiometric, optical sensors, encoders - absolute, incremental, touch and slip sensors velocity and acceleration sensors, proximity sensors, force& torque sensors, laser range finder, camera. Micro-controllers, DSP, centralized controllers, real time operating systems. Robot Controllers: Essential Components-Drive for Hydraulic and Pneumatic actuators, H-bridge drives for DC Motor with overload, over current and stall detection methods, example of a micro-controller/ microprocessor based- robot Controller. Micro-robotics and MEMS (Microelectro mechanical systems), fabrication technology for Micro-robotics, stability issue in legged robots, under-actuated manipulators. Robot Vision: Introduction, Image acquisition, Illumination Techniques, Image conversion, Cameras, sensors, Camera and system interface, Frame buffers and Grabbers, Image processing, low level & high level machine visionsystems.

Unit-11: Speech Processing

Introduction to speech processing - its necessity. Digital models for speech signals: process of speech production, acoustic theory of speech production, and models of speech production, auditory knowledge. Digital representation of speech waveform: sampling speech signals, quantization, delta modulation, differential PCM, code conversion, other new methods of coding. Fundamentals of speech analysis: background of speech processing tools, spectrographic analysis, short time analysis, time frequency analysis, homomorphic analysis. Linear predictive coding of speech: basic principles, solutions of LPC equations, prediction error, application of LPC parameters. Fundamentals of speech recognition: current state of speech recognition systems, techniques and problems for noisy speech recognition, statistical and speech model based methods. Speech enhancement: spectral subtraction, noise masking, and comb filtering, statistical modeling.

Click Here to Buy book on Flipkart

Downloaded from www.pdf.tube

CHAPTER 01
Transducers and Applications

2002
1. Which element in a generalized measurement system is the first to detect and respond to the physical measurand?
(A) Primary sensing element
(B) Signal conditioning element
(C) Variable conversion element
(D) Data presentation element

2008
2. Identify the INCORRECT statement regarding the architecture of a generalized measurement system.
(A) The transducer stage often includes both primary sensing and variable conversion.
(B) Data transmission elements are required when the display is remote from the sensor.
(C) Signal conditioning is exclusively used for amplifying low-amplitude signals.
(D) Display elements can be either analog indicators or digital readouts.

2019
3. What is the defining characteristic of an active transducer?
(A) It generates its output signal without auxiliary power.
(B) It requires an external electrical power source to operate.
(C) It outputs only discrete digital signals to the system.
(D) It inherently amplifies the measured physical quantity.

2010
4. Which of the following correctly pairs a transducer with its classification?
(A) Thermocouple - Passive electrical transducer
(B) LVDT - Active electromagnetic transducer
(C) Strain gauge - Primary mechanical transducer
(D) Piezoelectric crystal - Active transducer

2017
5. The minimum change in the input physical variable to which an instrument responds is defined as its:
(A) Accuracy
(B) Resolution
(C) Precision
(D) Hysteresis

2008
6. A sensor outputs 2.5 V for a 50 kPa input and 5.0 V for a 100 kPa input. Assuming strict linearity, what is its sensitivity?
(A) 0.02 V/kPa
(B) 0.05 V/kPa
(C) 20.0 kPa/V
(D) 50.0 kPa/V

NODIA

2010
7. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Precision guarantees accuracy in a measurement system.
Reason (R): Precision refers to the degree of agreement among repeated measurements of the same quantity under identical conditions.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2003
8. Which of the following is an example of a random error in measurement?
(A) Fluctuation in readings due to electronic noise
(B) Zero offset error in a pressure gauge
(C) Parallax error due to an observer's fixed position
(D) Use of an uncalibrated measuring scale

2005
9. Identify the INCORRECT pairing of static characteristic and its brief definition.
(A) Hysteresis - Difference in output for the same input when approached from different directions
(B) Range - The maximum rate of change of the output signal

(C) Repeatability - Closeness of output readings for the same input under identical conditions
(D) Linearity - The ability of an instrument to maintain a constant sensitivity across its range

2004

10. The time taken by a first-order system to reach 63.2% of its final steady-state value subjected to a step input is called the:
(A) Settling time
(B) Time constant
(C) Rise time
(D) Delay time

2023

11. Which order of measurement system is characterized by a damping ratio and a natural frequency?
(A) Zero-order system
(B) First-order system
(C) Second-order system
(D) Third-order system

2002

12. Evaluate the correct sequence of system dynamic response speed (fastest to slowest) to a step input, assuming standard typical designs.
(A) Zero-order → First-order → Second-order
(B) Second-order → Zero-order → First-order
(C) First-order → Zero-order → Second-order
(D) Zero-order → Second-order → First-order

2010

13. Consider the following statements about resistive potentiometers:
I. Conductive plastic potentiometers have essentially infinite resolution.
II. Wire-wound potentiometers suffer from finite resolution due to turn-to-turn jumps.
III. Electrical loading effects increase the linearity of potentiometers.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II
(D) I

2003

14. In resistive strain gauges, the piezoresistive effect primarily refers to the change in resistance due to:
(A) Variation in the ambient temperature of the environment
(B) Dimensional changes in the physical geometry alone
(C) Change in material resistivity under strain
(D) Variation in the applied input excitation voltage

2015

15. The gauge factor (GF) of a strain gauge is defined as:
(A) $\dfrac{\frac{\Delta L}{L}}{\frac{\Delta R}{R}}$
(B) $\dfrac{\frac{\Delta R}{R}}{\frac{\Delta L}{L}}$
(C) $\dfrac{\frac{\Delta \rho}{\rho}}{\frac{\Delta L}{L}}$
(D) $\dfrac{\frac{\Delta A}{A}}{\frac{\Delta R}{R}}$

2017

16. Match the elements with their functions in a Wheatstone bridge:
List I: (Elements)
P. Active gauge
Q. Dummy gauge
R. Galvanometer
S. Excitation source
List II: (Functions)
1. Temperature compensation
2. Imbalance detection
3. Strain measurement
4. Bridge power
(A) P-1, Q-3, R-2, S-4
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-1, R-2, S-4

2016

17. Which statement correctly distinguishes an LVDT from a simple resistive potentiometer?
(A) An LVDT has no physical contact between core and coils.
(B) An LVDT relies heavily on sliding resistive electrical contacts.
(C) An LVDT measures rotary angular displacement exclusively.
(D) An LVDT outputs a high DC voltage directly without signal conditioning.

2011

18. What causes residual null voltage in a Linear Variable Differential Transformer (LVDT)?

Click Here to Buy book on Amazon

(A) Perfect electrical symmetry in the secondary windings
(B) Excessive high-frequency DC excitation voltage
(C) Stray capacitance and magnetic imperfections
(D) The deliberate use of a non-magnetic core material

2001

19. For a parallel-plate capacitive displacement sensor, decreasing the air-gap distance causes the capacitance to:
(A) Increase non-linearly
(B) Decrease in a linear manner
(C) Remain completely constant
(D) Increase in a linear manner

2016

20. Consider the following statements about capacitive sensors:
I. Variable area sensors yield a linear relationship between displacement and capacitance.
II. Variable air-gap sensors are highly linear over large displacements.
III. Variable dielectric sensors are useful for liquid level measurement.
IV. Capacitive sensors are strictly active transducers.
Which of the above statements are correct?
(A) I, II and III
(B) I and III
(C) II, III and IV
(D) I and II

2007

21. Piezoelectric transducers are most suitable for measuring:
(A) Static pressure
(B) Dynamic vibration
(C) Constant force
(D) Steady-state temperature

2004

22. In an ultrasonic time-of-flight measurement system, the distance to the target is proportional to:
(A) The fundamental frequency of the transmitted ultrasonic pulse
(B) The peak amplitude of the returning reflected wave
(C) The total propagation time of the pulse
(D) The phase shift angle of the continuous wave

NODIA

2017

23. Bimetallic thermometers operate based on the principle of:
(A) The thermoelectric Seebeck effect between two dissimilar metals
(B) The change in internal electrical resistance with temperature
(C) The direct thermal emission of infrared electromagnetic radiation
(D) Unequal thermal expansion of bonded metals

2009

24. Identify the INCORRECT statement regarding Resistance Temperature Detectors (RTDs).
(A) They are highly sensitive and respond faster than thermistors.
(B) Platinum is commonly used due to its stability and linearity.
(C) They exhibit a positive temperature coefficient of resistance.
(D) Self-heating errors can occur if excitation current is too high.

2001

25. Thermistors typically exhibit which type of resistance-temperature characteristic?
(A) Linear positive temperature coefficient
(B) Non-linear negative temperature coefficient
(C) Highly linear negative temperature coefficient
(D) Zero temperature coefficient

2023

26. Which law of thermocouples states that introducing a third metal into the circuit will not affect the net EMF, provided the new junctions are at the same temperature?
(A) Law of Homogeneous Circuits
(B) Law of Intermediate Metals
(C) Law of Intermediate Temperatures
(D) Seebeck's First Law

2012

27. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Cold junction compensation is essential for accurate thermocouple measurements.
Reason (R): Thermocouples measure absolute temperature directly at the hot junction.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.

(D) A is false but R is true.

2025

28. Which standard thermocouple type utilizes Iron and Constantan?
(A) Type K
(B) Type T
(C) Type J
(D) Type E

2004

29. Dead-weight testers are primarily used for:
(A) Measuring dynamic pressure changes
(B) Measuring fluid flow rates
(C) Determining atmospheric humidity
(D) Calibrating pressure gauges

2009

30. Which elastic element is commonly coiled into a C-shape for pressure measurement?
(A) Diaphragm
(B) Bellows
(C) Bourdon tube
(D) Strain capsule

2003

31. The discharge coefficient (C_d) of a Venturi tube is typically:
(A) Less than 0.50
(B) Between 0.60 and 0.65
(C) Between 0.95 and 0.99
(D) Exactly 1.0

2022

32. Consider the following statements regarding obstruction flow meters:
I. Orifice meters cause higher permanent pressure loss than Venturi tubes.
II. Flow nozzles are less prone to wear than orifice plates.
III. Rotameters are constant-area, variable-pressure-drop devices.
IV. Venturi tubes are preferred for slurries and dirty fluids.
V. The flow rate in an orifice meter is directly proportional to the square root of the pressure drop.
Which of the above statements are correct?
(A) I, II, III and V
(B) I, II, IV and V
(C) II, III and IV
(D) I, III and V

2016

33. A Rotameter functions as a:
(A) Variable-area, constant-pressure-drop meter
(B) Constant-area, variable-pressure-drop meter
(C) Constant-area, constant-pressure-drop meter
(D) Variable-area, variable-pressure-drop meter

2019

34. Pitot-static tubes are used to determine fluid velocity by measuring the difference between:
(A) Dynamic pressure and absolute pressure
(B) Upstream pressure and vena contracta pressure
(C) Stagnation pressure and static pressure
(D) Head pressure and tail pressure

2019

35. Arrange the following obstruction flow meters in order of increasing permanent pressure drop:
I. Venturi tube
II. Flow nozzle
III. Orifice meter
(A) I, II, III
(B) I, III, II
(C) II, I, III
(D) III, II, I

2014

36. Hot-wire anemometers operate on the principle of:
(A) Electromagnetic induction
(B) Ultrasonic Doppler shift
(C) Vortex shedding frequencies
(D) Convective heat transfer

2004

37. Electromagnetic flow meters require the flowing fluid to be:
(A) Highly viscous fluids
(B) Conductive
(C) Optically transparent
(D) A compressible gas

2025

38. In a vortex shedding flow meter, the frequency of shed vortices is:
(A) Inversely proportional to fluid velocity
(B) Proportional to the square of fluid velocity
(C) Directly proportional to fluid velocity
(D) Independent of fluid velocity

2018

39. Seismic displacement pickups typically operate in a frequency region that is:
(A) Well below their natural frequency
(B) Exactly at their natural frequency
(C) Independent of their natural frequency
(D) Well above their natural frequency

Downloaded from www.pdf.tube

2002
40. Piezoelectric accelerometers are modeled mathematically as:
(A) Second-order systems
(B) First-order high-pass filters
(C) Zero-order systems
(D) Pure time-delay systems

2005
41. MEMS accelerometers frequently utilize which of the following mechanisms for sensing acceleration?
(A) Electromagnetic induction in a moving coil system
(B) Variable capacitive displacement
(C) Magnetic reluctance changes in a closed circuit
(D) High-resolution optical interferometry

2019
42. Proving rings are primarily used as standard devices for the measurement and calibration of:
(A) Torque
(B) Force
(C) Pressure
(D) Velocity

2011
43. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Bonded strain gauge load cells are temperature compensated.
Reason (R): Wheatstone bridge circuits with active and dummy gauges inherently cancel uniform temperature effects.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2022
44. Torque on a rotating shaft can be measured using strain gauges mounted at what angle to the shaft axis?
(A) 0 degrees
(B) 45 degrees
(C) 90 degrees
(D) 180 degrees

2005
45. Which sensor represents the most appropriate choice for measuring the torque of an engine continuously during rotation without using slip rings?
(A) Bonded rosette strain gauge directly wired to a static meter
(B) Dead-weight torque tester
(C) Variable reluctance force sensor
(D) Rotary transformer torque sensor

2013
46. Capacitive impedance hygrometers measure humidity by detecting changes in:
(A) The physical mass of a vibrating quartz crystal structure
(B) The dynamic thermal conductivity of surrounding air
(C) The dielectric constant of a polymer
(D) The propagation speed of sound through the sample gas

2011
47. Piezoelectric hygrometers determine moisture content based on:
(A) Generation of an electric charge proportional to ambient humidity
(B) Resonant frequency changes of the crystal
(C) Alteration of the optical refractive index of the crystal lattice
(D) The thermal Seebeck effect directly induced by water vapor

NODIA

2007
48. Consider the following statements concerning analytical pH measurement:
I. pH is defined as the negative logarithm of the hydrogen ion activity.
II. The Nernst equation relates the glass electrode potential to the pH of the solution.
III. Reference electrodes must generate a variable potential.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I
(D) II

2022
49. In a pH measurement system, the glass electrode serves as:
(A) An indicator electrode
(B) A stable reference electrode
(C) A standard grounding electrode
(D) A temperature thermocouple junction

2009

50. According to the Nernst equation at 25°C, a 1 unit change in pH results in an approximate change in electrode potential of:
(A) 10.5 mV
(B) 59.16 mV
(C) 100.0 mV
(D) 1.0 V

2016

51. The Stefan-Boltzmann law states that the total radiant exitance of a blackbody is proportional to:
(A) T^4
(B) T^2
(C) T^3
(D) λ_{max}

2015

52. Wien's displacement law indicates that as the temperature of a blackbody increases, its peak emission wavelength:
(A) Increases
(B) Remains constant
(C) Broadens uniformly across all spectra
(D) Decreases

2012

53. Match the radiation laws with their primary descriptors:
List I: (Laws)
P. Planck's Law
Q. Stefan-Boltzmann Law
R. Wien's Law
S. Kirchhoff's Law
List II: (Descriptors)
1. Emissivity equals absorptivity
2. Peak wavelength inversely proportional to temperature
3. Total radiated power proportional to T^4
4. Spectral distribution of radiation
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-4, Q-2, R-3, S-1
(D) P-1, Q-3, R-2, S-4

2012

54. Optical pyrometers are used to measure high temperatures by comparing the brightness of a source with:
(A) A standardized radioactive element source
(B) An absolute zero reference body
(C) A calibrated reference lamp filament
(D) An ultrasonic wave amplitude

2024

55. What is a key advantage of absolute position encoders over incremental encoders?
(A) They are mechanically simpler, highly robust, and cheaper to manufacture.
(B) They utilize a single continuous track of optical pattern windows.
(C) They output simple quadrature pulse trains for external decoding.
(D) They retain position data during power loss.

2023

56. Gray code is heavily preferred in digital absolute encoders because:
(A) Only one bit changes between adjacent positions.
(B) It represents numbers in standard base-10 format for digital systems.
(C) It inherently detects and corrects parity errors in digital transmission.
(D) It requires fewer physical tracks on the encoder disk than standard binary.

2012

57. Which option lists the correct sequence of signal processing in a digital encoder?
(A) Photodetector → Optical Disk → Light Source → Signal Conditioning
(B) Light Source → Optical Disk → Photodetector → Signal Conditioning
(C) Optical Disk → Light Source → Signal Conditioning → Photodetector
(D) Light Source → Photodetector → Optical Disk → Signal Conditioning

2025

58. Quartz crystal digital thermometers utilize the principle that the resonant frequency of specific quartz cuts is highly dependent on:
(A) Applied pressure
(B) Temperature
(C) Magnetic field strength
(D) Optical illumination

2005

59. Surface Acoustic Wave (SAW) sensors operate by converting electrical signals into:
(A) Acoustic waves on a piezoelectric surface
(B) High-frequency electromagnetic radiation waves
(C) Dynamic localized thermal temperature gradients
(D) Complex optical interference fringe patterns

Click Here to Buy book on Flipkart

2025

60. The Hall effect describes the generation of a transverse voltage in a current-carrying conductor when subjected to a perpendicular:
(A) Electric field
(B) Thermal gradient
(C) Magnetic field
(D) Mechanical stress

2016

61. Identify the INCORRECT statement concerning semiconductor junction thermometers.
(A) They rely on the temperature dependence of the forward voltage drop of a p-n junction.
(B) They are highly sensitive and inexpensive.
(C) They typically require a constant excitation current.
(D) The voltage drop increases linearly with an increase in temperature.

2012

62. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Photodiodes operate faster when reverse-biased.
Reason (R): Reverse biasing decreases the depletion region width, reducing the transit time of charge carriers.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

63. A phototransistor differs from a standard photodiode primarily in that it provides:
(A) A significantly faster response and recovery time
(B) Internal amplification of the photocurrent
(C) High sensitivity to a narrower spectral bandwidth of light
(D) A highly linear analog voltage output natively

2003

64. Charge-Coupled Devices (CCDs) function by:
(A) Emitting visible light from individual pixel semiconductor junctions
(B) Modulating the overall electrical resistance of a bulk semiconductor piece
(C) Deflecting a continuous electron beam magnetically across the screen
(D) Shifting photo-generated charge packets for readout

2011

65. Select the INCORRECT pair from the following transducer applications.
(A) Rotameter - Temperature measurement
(B) LVDT - Displacement distance measurement
(C) Load cell - Physical force measurement
(D) Bellows - Mechanical pressure measurement

2013

66. Consider the following statements about system errors:
I. Systematic errors can often be calibrated out.
II. Random errors follow normal statistical distributions.
III. Zero error is an example of a random error.
IV. Uncertainty analysis quantifies the estimated bounds of error.
Which of the above statements are correct?
(A) I, II and IV
(B) I and II
(C) II, III and IV
(D) I and IV

NODIA

2015

67. The phenomenon where a sensor output gradually changes over time despite a constant input is termed:
(A) Drift
(B) Hysteresis
(C) Resolution limit
(D) Dead band

2023

68. What effect does increasing the damping ratio (ζ) above 1.0 have on a second-order measurement system's step response?
(A) It causes sustained, undamped sinusoidal oscillations.
(B) It significantly speeds up the initial system rise time.
(C) It makes the physical system critically damped.
(D) It slows the response without overshoot.

2007

69. Match the term with its characteristic effect on dynamic response:
List I: (Terms)
P. Time constant
Q. Natural frequency
R. Phase shift
S. Damping ratio
List II: (Effects)

1. Determines speed of first-order systems
2. Inherent oscillation rate of second-order systems
3. Controls overshoot and decay rate
4. Delay between sinusoidal input and output

(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-1, Q-3, R-4, S-2
(D) P-3, Q-2, R-1, S-4

2025

70. When a first-order system is subjected to a ramp input, the steady-state dynamic error is:
(A) Exactly equal to zero at all times
(B) Infinite after a long duration of time
(C) Time constant times the ramp rate
(D) Dependent solely on the sensor's static gain value

2006

71. The principal disadvantage of wire-wound potentiometers in precision measurements is:
(A) High thermal instability under changing loads
(B) Extremely poor linearity across the entire range
(C) Strict requirement for high-frequency AC excitation
(D) Finite resolution from wire turns

2012

72. Rosette strain gauges are used to measure:
(A) Complex strains when directions are unknown
(B) Strain in a single, well-defined principal direction
(C) Pure mechanical torsion on a rotating shaft strictly
(D) Hydrostatic pressure under uniform loading conditions

2018

73. A dummy strain gauge in a Wheatstone bridge is subjected to:
(A) The same mechanical strain and temperature as the active gauge
(B) The same temperature but no mechanical strain
(C) No temperature variations but the same mechanical strain
(D) Neither temperature variations nor mechanical strain

2012

74. Consider the following statements about the Linear Variable Differential Transformer (LVDT):
I. The output voltage phase shifts by 180 degrees as the core passes through null.
II. It requires DC voltage for excitation.
III. It has infinite theoretical resolution.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II
(D) I

2002

75. A capacitive sensor measuring liquid level in a non-conductive tank relies on changes in:
(A) The dielectric constant
(B) Physical distance between the plates
(C) Overlapping surface area of the plates
(D) Electrical excitation frequency of the liquid

2021

76. In piezoelectric materials, the charge coefficient (d) relates:
(A) The output electrical voltage to the applied temperature change
(B) The total electrical capacitance to the material dielectric constant
(C) Induced charge to applied mechanical stress
(D) The physical displacement to the applied external magnetic field

NODIA

2016

77. Charge amplifiers are preferred over voltage amplifiers for piezoelectric sensors because they:
(A) Are completely immune to ambient temperature changes
(B) Provide a massive current gain for downstream devices
(C) Directly filter out high-frequency electromagnetic noise
(D) Eliminate the effect of cable capacitance

2002

78. Which sequence correctly orders the components of a time-of-flight ultrasonic measurement system?
(A) Transducer → Pulse Generator → Propagation Medium → Timer → Receiver
(B) Timer → Transducer → Propagation Medium → Pulse Generator → Receiver
(C) Pulse Generator → Transducer → Propagation Medium → Receiver → Timer
(D) Pulse Generator → Timer → Propagation Medium → Transducer → Receiver

2021

79. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): RTDs require an external current source for operation.

Reason (R): RTDs are passive transducers that change resistance with temperature.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2010

80. The Thomson effect involves the absorption or evolution of heat when current flows through a:

(A) An electrical junction made of two dissimilar metals
(B) A standard semiconductor p-n junction interface
(C) A crystalline piezoelectric crystal under physical load
(D) A single conductor with a temperature gradient

2008

81. Cold junction compensation in modern digital temperature measurement systems is typically achieved by:

(A) Using a terminal block temperature sensor
(B) Keeping the reference junction constantly in an ice bath
(C) Applying a constant reverse correction voltage to the thermocouple
(D) Using purely mechanical active bi-metallic strip mechanisms

2007

82. Which statement correctly identifies a distinct characteristic of a diaphragm pressure sensor?

(A) It is suitable only for extremely high-pressure hydraulic systems.
(B) It relies entirely on a liquid fill to amplify the applied force.
(C) Isolates the medium from the sensor via deflection.
(D) It works via the dynamic piezoelectric charge effect directly.

2010

83. The vena contracta in an orifice meter refers to:

(A) The point of minimum area and lowest pressure
(B) The physical upstream location where pressure is highest
(C) The physical metallic structure of the orifice plate device
(D) The gradual fluid expansion zone downstream of the meter

2013

84. Match the flow meter with its underlying operating principle:

List I: (Flow Meters)
P. Venturi tube
Q. Rotameter
R. Electromagnetic
S. Hot-wire anemometer

List II: (Operating Principles)
1. Faraday's Law of Induction
2. Bernoulli's principle (obstruction)
3. Heat transfer rate
4. Drag force balancing gravity

(A) P-1, Q-3, R-2, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-4, R-1, S-3

2016

85. Transit-time ultrasonic flow meters determine velocity based on:

(A) The frequency shift of scattered waves from moving particles
(B) Upstream and downstream transit-time difference
(C) The acoustic attenuation of the sound wave across the pipe diameter
(D) The physical formation of standing resonant acoustic waves

2018

86. Which application is least suited for a6 standard pitot-static tube?

(A) Aircraft airspeed measurement in high-altitude flights
(B) Wind tunnel velocity profiling under laminar conditions
(C) Viscous or particulate-laden flows
(D) Clean water flow rates in extremely large industrial pipes

2018

87. A gyroscopic angular sensor operates fundamentally based on the principle of:

(A) Variable magnetic reluctance in coils
(B) Fluid thermal convection currents
(C) High-frequency piezoelectric resonance
(D) Conservation of angular momentum

Downloaded from www.pdf.tube

2001

88. Consider the following statements regarding MEMS sensors:

I. They integrate mechanical elements and electronics on a common silicon substrate.

II. They are typically larger and more robust than traditional mechanical sensors.

III. They heavily utilize capacitive or piezoresistive sensing mechanisms.

IV. They are incapable of measuring dynamic accelerations.

Which of the above statements are correct?

(A) I and III

(B) I, II and III

(C) II and IV

(D) I and IV

2024

89. A variable reluctance force sensor translates mechanical force into a change in:

(A) Capacitance by moving parallel plates in a differential way

(B) Inductance by altering the magnetic air gap

(C) Electrical resistance by straining a metal wire

(D) Output voltage by generating a charge across crystal faces

2017

90. When measuring torque on a rotating shaft using strain gauges, slip rings are often utilized to:

(A) Mechanically secure the active strain gauges directly to the shaft surface

(B) Transfer signals between rotating and stationary parts

(C) Provide a non-contact magnetic coupling between rotating components

(D) Amplify the low-level gauge signals directly on the rotating shaft

2025

91. The dew point is fundamentally related to humidity measurement as the temperature at which:

(A) The air becomes saturated and condensation begins

(B) Water evaporates fastest

(C) The relative humidity reaches 50%

(D) The absolute humidity equals the atmospheric pressure

2011

92. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Ion-selective electrodes (ISEs) are sensitive ONLY to a single specific ion without any interference from other species.

Reason (R): Ion-selective electrodes operate on the principle of selective ion exchange at the membrane interface.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

2005

93. In a thermal radiation detector, the sensing element absorbs incident radiation and responds by:

(A) Releasing active photoelectrons from a sensitive cathode

(B) Emitting characteristic X-rays through high-energy decay

(C) Becoming mechanically stressed under intense physical force

(D) Altering physical properties via temperature change

NODIA

2014

94. Photon (quantum) detectors differ from thermal detectors in that they:

(A) Have a uniform spectral response across all incident wavelengths

(B) Depend entirely on the heating effect of the incoming radiation

(C) Respond directly to photon-excited electrons

(D) Are significantly slower in their overall response time

2003

95. Incremental digital encoders require a 'Z' or 'Index' channel primarily to:

(A) Determine the clockwise or counter-clockwise direction of rotation

(B) Provide a reference index once per revolution

(C) Measure the absolute rotational speed of the spinning shaft

(D) Power the optical emitter and photodetector sensor units

2010

96. Optical gratings in precise linear encoders typically exploit which physical phenomenon to achieve high resolution?

(A) Total internal reflection

(B) Blackbody radiation

(C) Chromatic dispersion

(D) Moiré fringe formation

2013

97. Consider the following statements about Quartz crystal thermometers:

I. They utilize the piezoelectric property of quartz.

II. The resonant frequency has a highly linear relationship with temperature over a specific range.

III. They are generally less accurate than standard K-type thermocouples.

Which of the above statements are correct?

(A) I and III

(B) II and III

(C) I and II

(D) II

2009

98. The primary mechanism underlying magneto-diodes is:

(A) The direct generation of a transverse Hall voltage in conductors

(B) The change in resistance of the bulk material due to piezoresistance

(C) Carrier deflection altering recombination rate

(D) The emission of coherent photons under an external magnetic field

2017

99. Match the semiconductor sensor with its primary physical phenomenon:

List I: (Sensors)

P. Hall effect sensor

Q. Semiconductor junction thermometer

R. Photodiode

S. Magneto-resistor

List II: (Phenomena)

1. Lorentz force on charge carriers
2. Carrier generation via photon absorption
3. Temperature dependence of forward voltage
4. Resistance change due to magnetic field

(A) P-1, Q-3, R-2, S-4

(B) P-4, Q-3, R-2, S-1

(C) P-1, Q-2, R-3, S-4

(D) P-2, Q-1, R-4, S-3

2024

100. In a CCD imaging sensor, the transfer of charge from one pixel to the next is analogous to a:

(A) Wheatstone bridge

(B) Random access memory matrix

(C) Multiplexed switch array

(D) Bucket brigade

2008

101. The phenomenon of hysteresis in an instrument is most likely caused by:

(A) High-frequency random electronic noise in the input amplifier stage

(B) Friction, magnetic saturation, or elastic lags

(C) Incorrect initial calibration of the system zero offset point

(D) Poor discrete resolution of the analog-to-digital converter

2003

102. Determine the correct sequence of steps for statistical evaluation of measurement data.

(A) Calculate Mean → Calculate Standard Deviation → Identify Outliers → Determine Confidence Interval

(B) Calculate Standard Deviation → Identify Outliers → Calculate Mean → Determine Confidence Interval

(C) Determine Confidence Interval → Calculate Mean → Calculate Standard Deviation → Identify Outliers

(D) Identify Outliers → Determine Confidence Interval → Calculate Mean → Calculate Standard Deviation

2016

103. If a measurement system has a sensitivity of 5 mV/°C and its digital display has a resolution of 1 mV, the temperature resolution of the system is:

(A) 0.2 °C

(B) 0.5 °C

(C) 1.0 °C

(D) 5.0 °C

2019

104. Which of the following best defines the term 'Accuracy'?

(A) Closeness of the reading to the true value

(B) The smallest measurable input physical change

(C) The standard spread of readings around the mean

(D) The dynamic ratio of output change to input change

2007

105. Consider the following statements:

I. Precision implies high accuracy.

II. Uncertainty analysis is used to find the exact true value.

III. Standard deviation is a measure of random error dispersion.

IV. Systematic errors can be reduced by taking

Click Here to Buy book on Amazon

multiple readings and averaging.

Which of the above statements are INCORRECT?

(A) I, II and IV
(B) I and II
(C) II, III and IV
(D) I, III and IV

2010

106. A first-order system with a time constant of 2 seconds is subjected to a step input. Approximately what percentage of its final reading will it reach after 6 seconds?

(A) 63.2%
(B) 86.5%
(C) 95.0%
(D) 99.3%

2024

107. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): A second-order system will oscillate if its damping ratio is less than 1.

Reason (R): An underdamped system contains complex conjugate roots leading to sinusoidal decay.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

108. When measuring a purely sinusoidal input, the dynamic error of a zero-order system is:

(A) Zero
(B) Dependent on the input frequency
(C) Infinite
(D) Proportional to the phase shift

2004

109. Which parameter dictates the theoretical resolution limit of a wire-wound potentiometer?

(A) The total resistance of the track
(B) The voltage applied to the ends
(C) The total number of turns of the resistance wire
(D) The speed of the wiper movement

2017

110. Temperature compensation in a semiconductor strain gauge is highly critical because:

(A) It has a very low gauge factor under standard stress.
(B) Semiconductors tend to melt easily at low temperatures.
(C) It inherently acts as an active thermocouple junction.
(D) Its piezoresistive effect is temperature-dependent.

2022

111. Identify the most appropriate configuration for maximizing the output sensitivity of a Wheatstone bridge measuring strain.

(A) One active gauge and three fixed resistors
(B) Two active gauges in opposite arms experiencing the same strain
(C) Four active gauges with two in tension and two in compression
(D) Four dummy gauges

2014

112. Match the displacement sensor with its fundamental property:

List I: (Sensors)
P. LVDT
Q. Conductive plastic potentiometer
R. Variable gap capacitive sensor
S. Optical encoder

List II: (Properties)
1. Non-linear relation over large range
2. Infinite resolution, analog contact
3. Digital pulse output
4. Mutual induction

(A) P-1, Q-3, R-2, S-4
(B) P-4, Q-2, R-1, S-3
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-4, R-3, S-1

2008

113. An LVDT produces a zero output voltage at the null position ideally. In practice, a small null voltage exists due to:

(A) Structural magnetic core material hysteresis
(B) Mechanical sliding contact wiper friction
(C) Localized temperature drift of the primary coil
(D) Excitation harmonics and stray capacitance

2018

114. Which statement is correct regarding capacitive variable-area sensors?

(A) Capacitance varies linearly with overlapping area
(B) They are highly sensitive to extremely small physical air gaps
(C) They are exclusively used for transient dynamic acceleration
(D) They require high-current low-voltage DC

NODIA

excitation power

2008

115. Consider the following statements regarding piezoelectric sensors:

I. They can measure true static inputs indefinitely.
II. They act as charge generators.
III. Quartz and Barium Titanate are common piezoelectric materials.
IV. They are well-suited for shock measurements.
V. Their output is entirely independent of temperature.

Which of the above statements are correct?

(A) II, III and IV
(B) I, II and III
(C) II, IV and V
(D) I, III and V

2002

116. In an uncompensated ultrasonic time-of-flight measurement system, how does an increase in ambient air temperature affect the measured distance reading for a fixed target?

(A) The distance reading increases because the actual speed of sound is higher.
(B) The distance reading decreases because the wave travels faster, resulting in a shorter transit time.
(C) The distance reading remains unchanged because transit time is independent of temperature.
(D) The distance reading decreases because the actual speed of sound is lower.

2008

117. Bimetallic strips bend when subjected to a temperature change because:

(A) The specific heat capacities of the chosen metals differ.
(B) Thermal conductivity rates vary widely between the metals.
(C) One bonded metal layer melts much before the other layer.
(D) Their coefficients of thermal expansion differ.

2015

118. Which of the following RTD materials provides the most linear response over a wide temperature range?

(A) Nickel
(B) Platinum
(C) Copper
(D) Tungsten

2004

119. Thermistors are manufactured primarily from:

(A) Pure noble metals like platinum
(B) Bonded bimetallic active alloys
(C) Sintered metal oxide mixtures
(D) Crystalline piezoelectric ceramics

2006

120. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): The Peltier effect is the exact reverse of the Seebeck effect.

Reason (R): The Peltier effect describes heat absorption or emission at a junction when a current is forced through it.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

121. The Type K thermocouple consists of which alloy pair?

(A) Chromel and Alumel
(B) Iron and Constantan
(C) Copper and Constantan
(D) Platinum and Rhodium

2021

122. Manometers measure pressure by balancing the applied pressure against:

(A) The mechanical tension of an elastic spring
(B) The hydrostatic head of a liquid column
(C) The physical deformation of a thin diaphragm
(D) An opposing electrodynamic magnetic field

2002

123. Determine the correct arrangement of elastic pressure elements in order of increasing pressure range suitability (lowest to highest generally).

I. Bellows
II. Diaphragm
III. Heavy-walled Bourdon tube

(A) I, II, III
(B) II, I, III
(C) I, III, II
(D) III, II, I

2019

124. The principle of the dead-weight tester is based on:

(A) Pascal's law and weights on a known piston area

Downloaded from www.pdf.tube

(B) Archimedes' principle of buoyant forces on submerged objects
(C) Bernoulli's dynamic equation of conservation of fluid energy
(D) Boyle's fundamental gas law of volumetric expansion

2024
125. Match the flow meter characteristic with its name:
List I: (Characteristics)
P. Highest permanent pressure loss
Q. Lowest permanent pressure loss
R. Variable area
S. Velocity point measurement
List II: (Names)
1. Rotameter
2. Pitot tube
3. Venturi tube
4. Orifice plate
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-1, R-3, S-2
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-3, R-1, S-4

2010
126. Which flow meter measures volumetric flow rate without introducing any significant pressure drop or obstruction into the pipe?
(A) Standard flow nozzle meter
(B) Sharp-edged orifice meter
(C) Variable-area rotameter
(D) Magnetic flow meter

2024
127. Consider the following statements about hot-wire anemometers:
I. They are primarily used for gas velocity measurement.
II. Constant Temperature Anemometry (CTA) is a common operating mode.
III. They are excellent for measuring highly turbulent flows.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2001
128. Doppler ultrasonic flow meters require the fluid to contain:
(A) A high concentration of fully dissolved active ions
(B) Reflective gas bubbles or suspended particles
(C) Completely pure, clean, and demineralized liquid
(D) Highly conductive, active magnetic particles

NODIA

2006
129. Seismic vibration sensors operating well above their natural frequency act as:
(A) Dynamic accelerometers
(B) Active velocity pickups
(C) High-range jerk meters
(D) Displacement pickups

2024
130. What is a principal advantage of a MEMS accelerometer over a conventional piezoelectric accelerometer?
(A) It can measure static (DC) accelerations like gravity.
(B) It generates higher voltage output without power.
(C) It handles extremely high temperature environments better.
(D) It relies on massive proof masses for ultra-high sensitivity

2011
131. In a piezoelectric accelerometer, the force exerted on the crystal is generated by:
(A) An external active mechanical linkage
(B) An electromagnetic solenoid coil
(C) Inertia of an internal proof mass
(D) Thermal expansion of the outer housing

2021
132. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Optical pyrometers can measure temperatures of targets placed inside vacuum chambers through glass windows.
Reason (R): The glass window does not absorb any radiant energy from the target.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013
133. Which force sensor relies on the elastic deformation of a machined steel ring?
(A) Piezoelectric load cell
(B) LVDT force gauge
(C) Hall effect force sensor
(D) Proving ring

2023

134. Variable reluctance sensors measure force by converting applied stress into a small displacement, which then alters the:
(A) Permeability of the central ferromagnetic core
(B) Magnetic reluctance via an air gap
(C) Inter-turn capacitance between the primary coils
(D) Total electrical resistance of the output winding

2011

135. Torque measurement on rotating shafts using optical methods relies on measuring the:
(A) Measurable change in surface color of the rotating shaft
(B) Localized temperature rise due to dynamic torsional strain
(C) Phase shift between two shaft-mounted wheels
(D) Transverse change in the outer diameter of the shaft

2016

136. A capacitive impedance hygrometer's sensing layer typically consists of:
(A) An active bimetallic metallic strip
(B) An ultra-pure crystalline silicon wafer
(C) A moisture-sensitive polymer dielectric
(D) A highly conductive composite metal oxide

2018

137. Which technique is commonly used to measure gas density directly?
(A) Measuring the electrochemical pH value of the gas
(B) Using a standard reference glass electrode system
(C) Determining the thermal Seebeck voltage coefficient
(D) Measuring the attenuation of ionizing gamma rays

2006

138. The pH of a neutral aqueous solution at 25°C is exactly 7.0. If the pH drops to 5.0, the hydrogen ion concentration has:
(A) Decreased by a factor of 100
(B) Decreased by a factor of 2
(C) Increased by a factor of 2
(D) Increased by a factor of 100

2025

139. Match the analytical element with its function:
List I: (Analytical Element)
P. Glass electrode
Q. Reference electrode (e.g., Ag/AgCl)
R. Nernst equation
S. Ion-selective membrane
List II: (Function)
1. Provides a stable baseline potential
2. Generates potential dependent on H^+
3. Relates cell potential to ion activity
4. Filters specific ions for detection
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-1, R-2, S-4

2025

140. Identify the most critical source of error in a glass pH electrode.
(A) Magnetic field interference
(B) Alkali error at high pH levels
(C) Variations in ambient light
(D) Changes in atmospheric pressure

2007

141. Planck's Law describes the:
(A) Spectral distribution of blackbody radiation
(B) Total electromagnetic power across all wavelengths
(C) Shift in the peak emission wavelength with temperature
(D) Equality of surface emissivity and spectral absorptivity

2014

142. Select the correct sequence of digital encoding complexity, from simplest position detection to highest reliability absolute position.
(A) Incremental Single-Channel → Incremental Quadrature → Binary Absolute → Gray Code Absolute
(B) Binary Absolute → Gray Code Absolute → Incremental Quadrature → Incremental Single-Channel
(C) Incremental Quadrature → Incremental Single-Channel → Gray Code Absolute → Binary Absolute
(D) Gray Code Absolute → Binary Absolute → Incremental Single-Channel → Incremental Quadrature

2013

143. Quadrature incremental encoders utilize two optical tracks offset by 90 electrical degrees in order to:
(A) Double the operating voltage
(B) Provide absolute position upon startup

Click Here to Buy book on Flipkart

(C) Eliminate mechanical jitter completely
(D) Discriminate the direction of movement

2006

144. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Absolute encoders do not lose their position data when powered off.
Reason (R): They read a unique physical code pattern for every position rather than counting pulses.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

145. Surface Acoustic Wave (SAW) sensors are often utilized as wireless, passive sensors because:
(A) They are equipped with a high-capacity, long-lasting internal battery.
(B) An interrogating RF pulse excites an acoustic wave, reflecting an echo.
(C) They utilize high-power active radio frequency signal transmitters.
(D) They emit synchronized and highly calibrated visible light pulses.

2019

146. Consider the following statements regarding Hall effect sensors:
I. They are commonly used for proximity switching and speed detection.
II. The Hall voltage is directly proportional to the magnetic flux density.
III. They require an excitation current to function.
IV. They only respond to changing magnetic fields, not static ones.
Which of the above statements are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I and III

2003

147. A magneto-transistor improves upon a standard Hall element by:
(A) Providing built-in signal amplification
(B) Requiring no continuous external power supply
(C) Sensing strictly localized thermal gradients
(D) Using purely simplified mechanical switching

2001

148. Photodiodes operated in photovoltaic mode (zero bias):
(A) Exhibit the highest response speed and bandwidth
(B) Require extremely large external high-voltage supplies
(C) Produce a light-proportional current with minimal dark current noise
(D) Are completely unaffected by ambient temperature shifts

2015

149. The architecture of a Charge-Coupled Device (CCD) inherently relies on:
(A) MOS capacitors storing photo-generated charge
(B) Elaborate arrays of mechanical microscopic mirrors
(C) Advanced piezoresistive silicon strain detection
(D) Thermoelectric cooling and temperature regulation

2016

150. An essential requirement for proper operation of a photomultiplier tube (PMT) compared to a solid-state photodiode is:
(A) High operating temperature
(B) An AC excitation signal
(C) A powerful external magnetic field
(D) A high-voltage power supply

2013

151. Which principle is used by an ultrasonic densitometer?
(A) Generation of a measurable electromotive force by fluid movement
(B) Dependence of acoustic impedance on fluid density
(C) Predictable alteration of the fluid's specific heat capacity
(D) Complete blocking of acoustic transmission by heavy fluids

2003

152. Match the optical component/sensor to its primary characteristic:
List I: (Optical Component)
P. Photomultiplier tube
Q. Photodiode (reverse-biased)
R. Phototransistor
S. CCD
List II: (Primary Characteristic)

Downloaded from www.pdf.tube

1. Highest speed, low internal gain
2. Image capture via charge transfer
3. Extremely high sensitivity via secondary emission
4. Moderate speed with internal current gain

(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-4, S-1

2013

153. A systematic error in a transducer calibration curve typically manifests as:
(A) Data points scattered randomly about a calculated best-fit line
(B) A sudden, momentary spike in a single isolated measurement
(C) Significant widening of the dynamic hysteresis loop
(D) A consistent offset or proportional deviation

2017

154. To evaluate the uncertainty in a result $R = x \cdot y$ where x and y have independent random uncertainties u_x and u_y, the relative uncertainty $\frac{u_R}{R}$ is given by:
(A) $\sqrt{\left(\frac{u_x}{x}\right)^2 + \left(\frac{u_y}{y}\right)^2}$
(B) $\frac{u_x}{x} + \frac{u_y}{y}$
(C) $u_x \cdot u_y$
(D) $\sqrt{u_x^2 + u_y^2}$

2003

155. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Increasing the gain of a measurement system always improves its signal-to-noise ratio.
Reason (R): Both the signal and the noise present at the input are amplified equally by a linear amplifier.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

156. In the context of dynamic characteristics, a system with a damping ratio $\zeta = 0$ is:
(A) Overdamped
(B) Undamped
(C) Critically damped
(D) Unstable

NODIA

2012

157. Which measurement instrument behaves most closely like a pure zero-order system?
(A) A high-quality linear resistive potentiometer
(B) A mercury-in-glass thermometer
(C) A heavily damped seismic mass accelerometer
(D) A Bourdon tube pressure gauge connected via a long capillary

2007

158. The phenomenon of "electrical loading" in a potentiometer circuit occurs when:
(A) The applied supply voltage exceeds the rated maximum limit
(B) The physical wiper friction generating localized thermal heat
(C) Significant loading current drawn by the output meter
(D) The internal wire resistance changing with ambient temperature

2015

159. Consider the following statements concerning strain gauges:
I. Foil strain gauges have better heat dissipation than wire gauges.
II. Transverse sensitivity is a desirable characteristic.
III. Semiconductor gauges have higher gauge factors than metal gauges.
IV. Creep is negligible in all bonded strain gauges.
Which of the above statements are correct?
(A) I and III
(B) I, II and IV
(C) II and III
(D) I and IV

2024

160. Which type of dummy gauge arrangement is most effective for temperature compensation?
(A) A highly sensitive RTD element placed directly adjacent to the active gauge.
(B) An identical gauge mounted perpendicular to the active gauge on the same specimen.
(C) An identical gauge on an unstrained block at the same temperature.
(D) A standard carbon composition resistor possessing the same nominal resistance.

2003

161. What is the fundamental difference between LVDT and RVDT?
(A) LVDT is a completely passive sensor, whereas RVDT is always active.
(B) LVDT measures linear displacement, RVDT measures rotary.
(C) LVDT requires high-frequency DC excitation, RVDT requires AC.
(D) LVDT works strictly on inductance, RVDT works on capacitance.

2001

162. Determine the correct chronological sequence of signal transformation in a standard LVDT setup.
(A) AC Excitation → Core Displacement → Differential AC Output → Phase-Sensitive Demodulation → DC Output
(B) Core Displacement → AC Excitation → Phase-Sensitive Demodulation → Differential AC Output → DC Output
(C) DC Excitation → Core Displacement → Differential DC Output → AC Modulation → DC Output
(D) AC Excitation → Core Displacement → Phase-Sensitive Demodulation → Differential AC Output → DC Output

2012

163. The primary reason for utilizing a phase-sensitive demodulator with an LVDT is to:
(A) Determine the direction of core displacement
(B) Amplify the raw analog output signal magnitude
(C) Eliminate all high-frequency environmental noise
(D) Convert the mechanical motion directly into digital pulses

2022

164. Match the temperature sensor to its fundamental material/phenomenon:
List I: (Temperature Sensor)
P. Thermocouple
Q. RTD
R. Thermistor
S. Bimetallic strip
List II: (Fundamental Material/Phenomenon)
1. Metal oxide semiconductor
2. Seebeck effect
3. Differential thermal expansion
4. Pure metal resistance
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-4, R-2, S-3

2007

165. Select the INCORRECT statement regarding the Law of Intermediate Temperatures.
(A) It necessitates that the intermediate temperature T_2 must be physically applied to an external junction.
(B) It allows a thermocouple calibrated for a specific reference temperature to be used with a different reference temperature.
(C) It states that EMF generated from T_1 to T_3 equals the sum of EMF from T_1 to T_2 and T_2 to T_3.
(D) It is fundamentally used in software-based cold junction compensation algorithms.

2005

166. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Elastic pressure sensors like Bourdon tubes suffer from hysteresis.
Reason (R): Perfectly elastic materials do not exist; some internal friction and structural memory remain during deformation cycles.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

167. Which device is recognized as a primary standard for pressure calibration?
(A) Bourdon tube
(B) Dead-weight tester
(C) Capacitive pressure transducer
(D) Bellows meter

2006

168. To measure a very low differential pressure (e.g., draft pressure in a furnace), the most appropriate instrument is:
(A) A heavy-duty Bourdon tube
(B) A dead-weight tester
(C) An inclined tube manometer
(D) A solid-state piezoelectric sensor

2007

169. What defines the "vena contracta" in fluid flow through an orifice?
(A) The physical point where the pipe diameter is at its absolute largest
(B) The specific spatial location of maximum

Click Here to Buy book on Amazon

static line pressure
(C) The physical thickness of the installed circular orifice plate
(D) The region of minimum flow cross-sectional area

2018
170. Which flow meter inherently measures mass flow rate without needing external density compensation?
(A) Coriolis flow meter
(B) Venturi tube
(C) Orifice plate
(D) Rotameter

2013
171. Consider the following flow meters:
I. Venturi tube
II. Electromagnetic flow meter
III. Orifice meter
IV. Rotameter
V. Flow nozzle
Which of the above flow meters are strictly variable-head (obstruction) types?
(A) I, III and V
(B) I, II and III
(C) III, IV and V
(D) I, IV and V

2021
172. The term "turn-down ratio" of a flow meter refers to:
(A) The ratio of incoming inlet pressure to outgoing outlet pressure
(B) The ratio of maximum to minimum measurable flow
(C) The physical linear tapering of a standard glass Rotameter tube
(D) The calculated ratio of turbulent to laminar fluid flow velocity

2021
173. Hot-wire anemometers are usually operated in Constant Temperature mode (CTA) rather than Constant Current mode (CCA) because CTA:
(A) Provides a much higher frequency response
(B) Consumes significantly less operating power overall
(C) Does not require an active feedback bridge circuit
(D) Is completely immune to ambient temperature changes

NODIA

2019
174. According to Faraday's Law, the induced voltage in an electromagnetic flow meter is directly proportional to:
(A) Fluid density
(B) Fluid viscosity
(C) Fluid velocity
(D) Pipe wall thickness

2005
175. Match the acceleration/vibration sensor to its key feature:
List I: (Sensor Type)
P. Seismic displacement pickup
Q. Piezoelectric accelerometer
R. MEMS piezoresistive accelerometer
S. Gyroscope
List II: (Key Feature)
1. Measures angular rate
2. Requires a soft spring (low natural frequency)
3. Measures DC (steady) acceleration
4. Self-generating, no DC response
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-3, S-1
(C) P-2, Q-3, R-4, S-1
(D) P-3, Q-4, R-2, S-1

2019
176. To measure angular velocity precisely in modern electronic systems without spinning mechanical masses, one would typically use a:
(A) A high-precision linear displacement LVDT
(B) A highly sensitive spiral Bourdon tube
(C) A vibratory MEMS gyroscope
(D) A standard variable-area rotameter

2017
177. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Bonded strain gauge load cells are preferred for dynamic high-frequency force measurement over piezoelectric sensors.
Reason (R): Strain gauge load cells typically have a massive structure leading to a low natural frequency.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004
178. A differential pressure sensor can be utilized to measure liquid density if:

(A) The liquid is flowing continuously at a constant high velocity.
(B) The measured liquid is determined to be completely non-conductive.
(C) The ambient temperature around the vessel fluctuates rapidly.
(D) Pressure is measured between two fixed vertical depths.

2019

179. Identify the correct statement regarding absolute humidity.
(A) It is the mass of water vapor per unit volume of moist air.
(B) It is the ratio of water vapor pressure to saturation vapor pressure.
(C) It is synonymous with the dew point temperature.
(D) It changes drastically with temperature even if no moisture is added or removed.

2003

180. Which instrument is considered a fundamental, primary method for measuring humidity?
(A) An advanced capacitive polymer sensor
(B) A high-sensitivity resistive ceramic sensor
(C) A chilled-mirror dew point hygrometer
(D) A traditional mechanical hair hygrometer

2002

181. Consider the following statements concerning analytical electrodes:
I. The Nernst equation slope is temperature-dependent.
II. Reference electrodes provide a variable potential for comparison.
III. Glass electrodes require high-impedance amplifiers due to their high internal resistance.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I, II and III

2009

182. Thermal detectors for radiation (e.g., bolometers, thermopiles) typically exhibit a spectral response that is:
(A) Narrow and highly peaked at visible wavelengths
(B) Dependent strictly on the photon energy exceeding the bandgap
(C) Limited exclusively to the ultraviolet spectrum
(D) Broad and relatively flat across a wide range of wavelengths

2011

183. If a blackbody's absolute temperature doubles, the total radiant power emitted increases by a factor of:
(A) 2
(B) 4
(C) 8
(D) 16

2023

184. In an absolute optical encoder, a 10-track disk provides an angular resolution of approximately:
(A) 0.01 degrees
(B) 0.35 degrees
(C) 1.00 degree
(D) 36.00 degrees

2013

185. Consider the following statements about Gray code:
I. It is an unweighted binary code.
II. It is highly susceptible to multi-bit read errors at transition boundaries.
III. It can be easily converted to standard binary using XOR logic.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I

2002

186. Match the advanced sensor to its operating principle:
List I: (Sensor Type)
P. SAW sensor
Q. Magneto-diode
R. Phototransistor
S. Quartz thermometer
List II: (Operating Principle)
1. Base current generated by photons
2. Resonant frequency shift with temperature
3. Acoustic wave propagation on a crystal
4. Recombination rate altered by magnetic field
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-1, S-2
(C) P-3, Q-4, R-2, S-1
(D) P-2, Q-4, R-1, S-3

Downloaded from www.pdf.tube

2012

187. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Surface Acoustic Wave (SAW) sensors can operate without an onboard battery.
Reason (R): They can harvest the energy of the interrogating RF pulse to generate the return signal.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

188. Which magnetic sensing technology utilizes the quantum mechanical magnetoresistance effect observed in thin-film structures composed of alternating ferromagnetic and non-magnetic conductive layers?
(A) Hall effect sensor
(B) Fluxgate magnetometer
(C) Giant Magnetoresistance (GMR) sensor
(D) Magneto-diode

2002

189. A Charge-Coupled Device (CCD) suffers from a phenomenon where excess charge spills over into adjacent pixels under bright illumination. This is called:
(A) Blooming
(B) Dark current
(C) Aliasing
(D) Shot noise

2014

190. What is a primary cause of dark current in optical imaging sensors?
(A) External stray light leaking directly into the housing
(B) High-energy cosmic ray strikes on the active area
(C) Thermal generation of electron-hole pairs
(D) Localized electromagnetic and magnetic field interference

2013

191. Determine the correct sequence of action in a generic digital data acquisition system.
(A) Transducer → Signal Conditioning → Anti-aliasing Filter → ADC → Microprocessor
(B) Transducer → ADC → Anti-aliasing Filter → Signal Conditioning → Microprocessor
(C) ADC → Transducer → Signal Conditioning → Anti-aliasing Filter → Microprocessor
(D) Transducer → Signal Conditioning → ADC → Anti-aliasing Filter → Microprocessor

2022

192. Which statement correctly describes a "zero-order" measurement system?
(A) It exhibits an exceptionally large thermal time constant.
(B) It suffers heavily from resonance at its design natural frequency.
(C) Its output instantaneously follows the input.
(D) It requires solving a second-order differential equation to find its output.

2003

193. The resolution of an analog moving-coil voltmeter is primarily limited by:
(A) The total number of resolution bits in the ADC system
(B) The scale readability of the pointer
(C) The processing speed of the internal micro-controller
(D) The electrical frequency of the incoming AC supply voltage

NODIA

2008

194. If a temperature sensor has a variance of 0.04 $°C^2$ in its readings, the standard deviation is:
(A) 0.0016 °C
(B) 0.04 °C
(C) 0.16 °C
(D) 0.20 °C

2016

195. Match the error type to its appropriate mitigation strategy:
List I: (Error Type)
P. Parallax error
Q. Random electronic noise
R. Environmental temperature drift
S. Zero offset error
List II: (Mitigation Strategy)
1. Calibration adjustment
2. Mirror behind the pointer to align line of sight
3. Active temperature compensation
4. Signal averaging / low-pass filtering
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-1, Q-4, R-3, S-2
(D) P-2, Q-1, R-3, S-4

2002

196. Consider the following statements about system dynamic responses:

I. A first-order system exhibits overshoot if excited by a large step input.
II. A second-order system will oscillate if the damping ratio is less than 1.
III. The dynamic error to a unit ramp input for a first-order system in steady state is equal to the time constant.

Which of the above statements are correct?
(A) II and III
(B) I and II
(C) I and III
(D) I, II and III

2009

197. Which design modification would most effectively decrease the time constant of a bare thermocouple?
(A) Decreasing the physical junction mass
(B) Significantly increasing the wire diameter
(C) Enclosing the sensor in a thick metal thermowell
(D) Adding a heavy protective layer of ceramic insulation

2001

198. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Potentiometers act as variable voltage dividers.
Reason (R): The wiper position proportionally divides the total resistance, outputting a fraction of the excitation voltage.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024

199. When selecting a strain gauge for a high-temperature environment, which parameter is most critical to match with the test specimen?
(A) Overall structural thermal conductivity
(B) Thermal expansion coefficient
(C) Volumetric specific heat capacity
(D) Temperature-dependent electrical resistivity

2022

200. What is the effect of using long lead wires with a quarter-bridge strain gauge circuit?
(A) It significantly increases the overall measurement sensitivity of the active gauge.
(B) It completely eliminates any technical need for temperature dummy gauges.
(C) It causes signal attenuation and temperature errors.
(D) It creates a perfectly balanced electrical Wheatstone bridge inherently.

2004

201. Which LVDT configuration yields exactly zero output at the center position?
(A) Series aiding configuration of the two secondaries
(B) Direct parallel connection of both secondary coils
(C) Completely grounding the primary excitation coil
(D) Series opposing connection of secondaries

2001

202. The sensitivity of a parallel-plate variable air-gap capacitive sensor is inversely proportional to:
(A) The square of the gap distance
(B) The area of the plates
(C) The dielectric constant
(D) The frequency of the AC excitation

2008

203. Consider the following statements about ultrasonic transducers:
I. They typically operate in the MHz frequency range.
II. A coupling medium (like gel) is often required for solid contact to prevent severe acoustic reflection.
III. They cannot measure distance in gases.

Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2017

204. Match the temperature measurement technology to its typical application range limitation:
List I: (Temperature Measurement Technology)
P. Platinum RTD
Q. Semiconductor thermistor
R. Optical pyrometer
List II: (Application Range Limitation)
1. > 1500 °C
2. ~ 850 °C
3. ~ 300 °C
(A) P-2, Q-3, R-1
(B) P-3, Q-2, R-1
(C) P-1, Q-3, R-2

Click Here to Buy book on Flipkart

(D) P-2, Q-1, R-3

2007

205. Which thermocouple is noted for its extremely high stability and is often used as a standard for calibration?
(A) Type S (Platinum/Rhodium)
(B) Type J (Iron/Constantan alloy)
(C) Type K (Chromel/Alumel alloy)
(D) Type T (Copper/Constantan alloy)

2023

206. A diaphragm pressure sensor relies on measuring the deflection of the diaphragm. Which secondary transducer is least commonly used to measure this deflection?
(A) Strain gauge
(B) LVDT
(C) Rotameter
(D) Capacitive gap sensor

2016

207. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): An orifice meter requires a longer straight pipe run upstream compared to a Venturi tube.
Reason (R): The orifice plate creates a more severe flow disturbance and requires fully developed flow for accurate coefficient application.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

208. In a Rotameter, the float stabilizes at a given height when:
(A) The upward buoyant force exactly equals the downward force of gravity.
(B) The dynamic line pressure strictly equals the localized static pressure.
(C) Upward forces balance downward gravity.
(D) The internal fluid flow within the tube becomes fully turbulent.

2008

209. Electromagnetic flow meters obey Faraday's Law of Induction, represented by the equation $E = B \cdot l \cdot v$. In this equation, l represents:
(A) The overall physical length of the flow pipe
(B) The distance between the electrodes
(C) The total electrical inductance of the coil
(D) The mass density of the flowing process fluid

2007

210. The Strouhal number is a dimensionless parameter primarily associated with which flow meter?
(A) Venturi tube
(B) Orifice plate
(C) Electromagnetic flow meter
(D) Vortex shedding flow meter

2002

211. Which accelerometer configuration inherently features an extremely high resonant frequency and ruggedness but cannot measure static acceleration?
(A) Piezoelectric accelerometer
(B) Strain gauge accelerometer
(C) Capacitive MEMS accelerometer
(D) LVDT-based accelerometer

2001

212. Consider the following statements concerning proving rings:
I. They are widely used as calibration standards for force measurement.
II. Deflection is traditionally measured via a precise micrometer or vibrating reed.
III. They are highly sensitive to temperature changes, requiring compensation.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I

2011

213. Match the physical quantity to a sensor commonly used to measure it:
List I: (Physical Quantity)
P. Relative humidity
Q. Shaft torque
R. pH
S. Vibration (displacement)
List II: (Sensor Type)
1. Seismic pickup
2. Glass electrode
3. Bonded strain gauges at 45°
4. Capacitive polymer hygrometer
(A) P-4, Q-3, R-2, S-1
(B) P-1, Q-4, R-2, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-4, Q-2, R-3, S-1

NODIA

2001

214. In pH measurement, the standard hydrogen electrode (SHE) is theoretically assigned a potential of:
(A) 1.00 V maintained at exactly 25 °C
(B) -0.59 V maintained at exactly 25 °C
(C) 7.00 V maintained at exactly 25 °C
(D) 0.00 V at all temperatures

2010

215. The term "blackbody" in radiation sensing refers to an idealized object that:
(A) Reflects all incoming and incident thermal radiation
(B) Absorbs all radiation and is a perfect emitter
(C) Transmits all incident radiation without any absorption
(D) Only emits thermal radiation in the visible wave spectrum

2015

216. Optical gratings utilizing Moiré fringes typically consist of:
(A) A single highly polished prism paired with a photodetector
(B) A concave reflective mirror aligned with a convex glass lens
(C) Two gratings superimposed at a slight angle
(D) Two polarizing optical filters rotated exactly 90 degrees

2011

217. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Gray code is universally used in absolute optical encoders.
Reason (R): Changing between any two consecutive values in Gray code involves changing multiple bits simultaneously, which speeds up processing.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

218. SAW (Surface Acoustic Wave) sensors can measure chemical concentrations if the delay line is:
(A) Coated with a mass-sensitive selective polymer
(B) Made of purely reflective and highly polished metals
(C) Heated to a high temperature to vaporize the target chemical
(D) Submerged entirely in a highly conductive aqueous fluid

2017

219. Identify the INCORRECT statement concerning Hall effect sensors.
(A) The Hall voltage is inversely proportional to the thickness of the Hall element.
(B) They are exclusively used for detecting high-frequency AC magnetic fields.
(C) Semiconductors generally produce a much larger Hall voltage than metals.
(D) They can be used as proximity sensors when paired with a permanent magnet.

2011

220. The primary advantage of a phototransistor over a photodiode is:
(A) Considerably faster overall dynamic response time
(B) Inherent signal amplification
(C) Much broader and uniform spectral operating bandwidth
(D) Ability to operate reliably without any external bias voltage

2024

221. Consider the following statements about imaging sensors:
I. CCDs transport charge across the chip to a single readout amplifier.
II. CMOS sensors generally have an amplifier for each pixel.
III. CCDs inherently suffer more from rolling shutter artifacts than typical CMOS.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

NODIA

2024

222. In the context of a generalized measurement system, a telemetry link falls under the category of:
(A) Primary sensing element
(B) Signal manipulation element
(C) Data transmission element
(D) Variable conversion element

2002

223. What distinguishes an analog transducer from a digital transducer?
(A) Analog transducers require no power,

whereas digital ones always do.
(B) Analog transducers only measure temperature, while digital ones measure any variable.
(C) Analog transducers are always classified as primary physical sensors.
(D) Analog output is continuous, digital is discrete.

2018
224. Which of the following defines the 'span' of an instrument?
(A) The lowest valid and calibrated reading of the instrument
(B) The mathematical arithmetic average of all taken readings
(C) Difference between upper and lower range values
(D) The overall calculated percentage degree of system linearity

2016
225. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Hysteresis leads to a different output for a given input depending on the direction of input variation.
Reason (R): Magnetic or elastic memories in the sensor materials resist returning precisely to their original state.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011
226. Standard deviation is preferred over simple variance in reporting error bounds primarily because:
(A) It is always a mathematically smaller statistical number.
(B) It completely eliminates all possible systematic errors.
(C) It inherently guarantees a 99% confidence interval limit.
(D) It has the same units as the variable.

2011
227. Match the dynamic specification to its physical meaning:
List I: (Dynamic Specification)
P. Rise time
Q. Settling time
R. Peak overshoot
S. Phase shift
List II: (Physical Meaning)
1. Max deviation past the final steady-state value
2. Time to stay within a specified error band
3. Delay in angular degrees for a sine wave input
4. Time to go from 10% to 90% of final value
(A) P-4, Q-2, R-1, S-3
(B) P-2, Q-4, R-3, S-1
(C) P-1, Q-3, R-2, S-4
(D) P-4, Q-1, R-2, S-3

2014
228. Which first-order dynamic system characteristic causes a dynamic error when responding to a ramp input?
(A) Natural frequency
(B) Signal amplification
(C) Time constant
(D) Hysteresis band

2014
229. A second-order instrument has a natural frequency of 100 Hz and a damping ratio of 0.707. What describes its step response?
(A) It will overshoot slightly and settle rapidly.
(B) It will not overshoot or oscillate under any conditions.
(C) It will exhibit completely sustained, undecaying oscillations.
(D) It will respond precisely as a pure first-order system would.

2011
230. The resistance of a wire-wound potentiometer is 1000 ohms, and it has 500 turns. What is its theoretical resolution?
(A) 0.1%
(B) 0.2%
(C) 0.5%
(D) 1.0%

2006
231. Consider the following statements about strain gauges:
I. The gauge factor is mostly derived from dimensional changes in metals.
II. Piezoresistive effect dominates the gauge factor in semiconductor gauges.
III. Semiconductor gauges have high sensitivity but poor temperature stability.
Which of the above statements are correct?

Downloaded from www.pdf.tube

(A) I and II
(B) II and III
(C) I, II and III
(D) I and III

2004

232. In LVDT operation, exactly what is modulated by the core's motion?
(A) The overall electrical resistance of the primary coil
(B) The parasitic capacitance between primary and secondary coils
(C) The mutual inductance between coils
(D) The fundamental frequency of the AC excitation voltage

2007

233. A variable dielectric capacitive sensor is particularly well-suited for:
(A) Measuring the exact thickness of a highly conductive metal sheet
(B) Measuring extremely low ultra-high chamber vacuum pressures
(C) Sensing very high frequency mechanical surface vibrations
(D) Detecting the level of a non-conducting liquid

2022

234. Piezoelectric coefficients are represented by a 'd' constant. For Quartz, this constant is approximately:
(A) 0.01 pC/N
(B) 2.3 pC/N
(C) 250 pC/N
(D) 1000 pC/N

2015

235. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Charge amplifiers are insensitive to the capacitance of the cable connecting the piezoelectric sensor to the amplifier.
Reason (R): Charge amplifiers maintain an effective zero voltage across the input terminals, preventing charge accumulation on the cable capacitance.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2003

236. A bimetallic thermometer fundamentally relies on which mechanical action to provide a reading?
(A) Structural shearing of metals
(B) Bending due to differential expansion
(C) Pure mechanical twisting or torsion
(D) Direct and continuous longitudinal compression

2018

237. Match the temperature measurement challenge with the most appropriate sensor:
List I: (Temperature Measurement Challenge)
P. Measurement of a furnace at 1400 °C
Q. Highly precise lab measurement at 100 °C
R. Low-cost, robust industrial monitoring up to 500 °C
S. Tiny point-measurement with fast response
List II: (Sensor Type)
1. Platinum RTD
2. Type J Thermocouple
3. Type S Thermocouple or Optical Pyrometer
4. Fine-wire bare thermocouple
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-4, S-3

2025

238. Cold junction compensation in thermocouple circuits is required because:
(A) The hot sensing junction always cools down far too quickly.
(B) The extension leads have high resistance that must be offset.
(C) Voltage depends on the difference between two junctions.
(D) Standard laboratory voltmeters draw an excessive input current.

2017

239. Dead-weight testers must incorporate a fluid to operate. Which fluid is commonly used for high-pressure calibration?
(A) Mercury
(B) Compressed air
(C) Pure water
(D) Hydraulic oil

2008

240. The restoring force in a diaphragm pressure transducer is provided by:
(A) An adjustable external coiled tension spring
(B) An active, externally generated magnetic field
(C) Stiffness of the diaphragm material

NODIA

(D) The pressure of the trapped reference gas

2015

241. Consider the following statements regarding the Pitot-static tube:

I. It determines velocity by measuring dynamic pressure.

II. It requires careful alignment with the flow direction.

III. It provides a highly accurate average bulk flow reading in turbulent pipes.

Which of the above statements are correct?

(A) I and II

(B) II and III

(C) I and III

(D) I

2025

242. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Electromagnetic flow meters cause zero permanent pressure drop.

Reason (R): They do not introduce any obstruction into the flow path.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

2012

243. In vortex shedding flow meters, the shedding frequency is directly measured using:

(A) A downstream pressure sensor

(B) A precise variable area float assembly

(C) A high-sensitivity exposed thermocouple

(D) An absolute multi-track optical encoder

2018

244. A seismic mass displacement pickup must have a natural frequency that is:

(A) Much higher than the vibration frequency being measured

(B) Exactly equal to the vibration frequency

(C) Much lower than the vibration frequency being measured

(D) Continuously varied to match the vibration

2002

245. Match the MEMS sensor element to its typical function:

List I: (MEMS Sensor Element)

P. Proof mass

Q. Comb fingers

R. Suspension springs

S. Damping medium (gas)

List II: (Typical Function)

1. Determines the natural frequency (stiffness)
2. Generates inertial force during acceleration
3. Prevents excessive resonance peaking
4. Forms a variable capacitor array

(A) P-2, Q-4, R-1, S-3

(B) P-1, Q-3, R-4, S-2

(C) P-2, Q-1, R-4, S-3

(D) P-4, Q-2, R-1, S-3

2002

246. Which arrangement of strain gauges on a cylindrical shaft provides the best sensitivity for pure torque measurement while canceling axial and bending strains?

(A) Two gauges aligned axially, spaced exactly 180 degrees apart

(B) Four gauges aligned axially, spaced exactly 90 degrees apart

(C) A single gauge wrapped circumferentially around the solid shaft

(D) Four 45-degree gauges in a full bridge

2002

247. Proving rings are classified as an elastic force measuring standard. The deflection of the ring is proportional to:

(A) The cube of the applied force

(B) The applied force linearly

(C) The square root of the applied force

(D) The natural log of the applied force

2023

248. Hygrometers using capacitive sensors typically have a polymer layer that:

(A) Rapidly heats up when exposed directly to moisture

(B) Dissolves proportionally to the level of ambient humidity

(C) Absorbs moisture, changing its dielectric constant

(D) Generates a measurable transverse Hall voltage output

2005

249. Which method is most effective for measuring the density of a continuous liquid flow without contacting the liquid?

(A) A standardized physical displacement float

(B) A direct gravitational mass weighing tank system

(C) A calibrated scientific glass hydrometer tube

(D) An ultrasonic densitometer

Click Here to Buy book on Amazon

2013

250. According to the Nernst equation, the potential of an ion-selective electrode depends on the logarithm of the:
(A) Activity of the target ion
(B) Thermodynamic temperature of the solution
(C) Total volumetric volume of the solution
(D) Total electrical conductivity of the solution

2001

251. Consider the following statements concerning optical pyrometers:
I. They utilize the human eye or a photodetector to match brightness.
II. They operate based on Planck's law of radiation.
III. They are restricted to measuring temperatures below 500 °C.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2022

252. Which encoding scheme prevents large position errors in absolute digital encoders by ensuring only one bit changes at a time?
(A) Binary Coded Decimal (BCD)
(B) Gray Code
(C) ASCII
(D) Hexadecimal

2010

253. Surface Acoustic Wave (SAW) sensors heavily depend on which fundamental material property?
(A) Piezoelectricity
(B) Ferromagnetism
(C) Thermoelectricity
(D) Photoemission

2023

254. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Photodiodes operated in photoconductive mode (reverse bias) have a larger depletion region.
Reason (R): The reverse bias increases the electric field across the junction, improving response speed by sweeping carriers faster.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

255. The Hall effect is most pronounced in which class of materials?
(A) Pure noble metals
(B) Superconductors
(C) Ferromagnetic insulators
(D) Semiconductors

2019

256. A Charge-Coupled Device (CCD) shifts pixel charge packets by manipulating:
(A) Highly stabilized, small permanent magnets
(B) Ultra-thin flexible piezoresistive membranes
(C) Clocked gate voltages to form potential wells
(D) Continuous mechanical vibration of the silicon substrate

NODIA

2022

257. Which measurement parameter best describes the extent to which an instrument replicates the same output for repeated applications of the same input?
(A) Linearity
(B) Repeatability
(C) Sensitivity
(D) Resolution

2001

258. In the evaluation of measurement data, identifying a 'systematic error' means finding an error that is:
(A) Random and follows a standard Gaussian distribution
(B) Unpredictable and caused by environmental noise
(C) Entirely due to human mistake in transcription
(D) Predictable and consistent

2001

259. A measurement system with a damping ratio $\zeta = 0.5$ is considered:
(A) Underdamped
(B) Overdamped
(C) Critically damped
(D) Undamped

2009

260. Match the physical property to the fundamental sensor type:
List I: (Physical Property)
P. Change in resistance due to strain
Q. Change in voltage due to temperature gradient

R. Change in capacitance due to plate movement
S. Change in charge due to applied force

List II: (Sensor Type)

1. Thermocouple
2. Strain gauge
3. Piezoelectric crystal
4. Capacitive micrometer

(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-1, R-2, S-3
(D) P-2, Q-4, R-1, S-3

2017

261. An LVDT features one primary coil and how many secondary coils?
(A) One
(B) Two
(C) Three
(D) Four

2014

262. Consider the following statements about Resistance Temperature Detectors (RTDs):
I. They exhibit a positive temperature coefficient.
II. Self-heating can cause significant measurement error.
III. They operate based on the Seebeck effect.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2014

263. When calibrating a pressure gauge with a dead-weight tester, the area of the piston must be known precisely to calculate:
(A) The fluid viscosity
(B) The actual applied pressure
(C) The atmospheric humidity
(D) The ambient temperature compensation

2002

264. The primary limitation of a standard orifice plate flow meter compared to a Venturi tube is:
(A) Significantly higher overall cost of manufacture
(B) Complete inability to measure dynamic gas flow
(C) High non-recoverable pressure loss
(D) Extremely large physical installation footprint

2015

265. What causes the 'Coriolis force' used in Coriolis mass flow meters?
(A) The active interaction between a static magnetic field and fluid ions
(B) The periodic shedding of dynamic vortices directly behind a bluff body
(C) The differential thermal expansion of the external metallic meter body
(D) Simultaneous rotation of a tube and internal fluid flow

2019

266. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Capacitive accelerometers can measure the static acceleration of gravity.
Reason (R): The proof mass deflects under a constant DC acceleration, changing the steady-state gap distance and therefore the capacitance.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012

267. Variable reluctance force sensors require an electronic oscillator because they operate by:
(A) Generating continuous DC voltage directly from physical motion
(B) Changing coil inductance in an AC circuit
(C) Modulating the intensity of a constant laser beam
(D) Utilizing the transverse piezoelectric effect

2005

268. In an ion-selective electrode, the function of the reference electrode is to:
(A) Attract target ions physically to the membrane
(B) Provide a stable, known potential
(C) Measure the real-time temperature of the solution
(D) Continuous agitation of the dynamic solution

2006

269. Consider the following statements about digital position encoders:
I. Incremental encoders lose their absolute position upon power failure.
II. Absolute encoders output a unique binary or Gray code word for each position.
III. Optical gratings in encoders use Moiré

Downloaded from www.pdf.tube

fringes to enhance resolution.

Which of the above statements are correct?

(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2021

270. A magneto-diode typically features a high sensitivity to magnetic fields due to the modulation of:

(A) The total physical length of the active diode
(B) The overall thermal conductivity of the semiconductor material
(C) Recombination rate of deflected carriers
(D) The intrinsic bandgap energy of the host silicon substrate

****

NODIA

ANSWERS

1. (A) Primary sensing element
The primary sensing element in a generalized measurement system is the component that first interacts with the physical quantity being measured. It detects the measurand and produces a corresponding output signal, which is typically a mechanical or electrical variation. This initial conversion is critical as it sets the baseline for all subsequent signal conditioning steps.

2. (C) Signal conditioning is exclusively used for amplifying low-amplitude signals.
Signal conditioning elements perform multiple functions beyond simple amplification of low-level signals. These operations include filtering to remove noise, linearizing non-linear relationships, modulating or demodulating carrier waves, and performing analog-to-digital conversion. Restricting this stage to amplification is incorrect because processing signals involves preparing them comprehensively for subsequent storage, transmission, or display.

3. (A) It generates its output signal without auxiliary power.
Active transducers are self-generating devices that convert energy from one form to another without requiring an external electrical power source. They utilize energy directly from the input physical measurand to produce an electrical output signal, such as charge or voltage. This characteristic distinguishes them from passive transducers, which require auxiliary power to operate.

4. (D) Piezoelectric crystal - Active transducer
A piezoelectric crystal generates an electrical charge directly when subjected to mechanical stress, operating as a self-generating active transducer without requiring external electrical power. Other devices like thermocouples are active thermal sensors, whereas linear variable differential transformers and strain gauges are passive electrical devices because they need external excitation power to generate a measurable output.

5. (B) Resolution
Resolution is the smallest increment of input variable change that a measurement instrument can reliably detect and indicate. While accuracy concerns proximity to the true value and precision represents reproducibility, resolution specifically quantifies the finite limits of a device to register minute variations, which is critical for choosing sensors for high-precision applications.

6. (B) 0.05 V/kPa
Sensitivity is defined as the ratio of change in output signal to change in input physical quantity. For an input change from fifty to one hundred kilopascals, the variation is fifty kilopascals, while the corresponding voltage output changes by two point five volts. Dividing this output change by the input change yields the sensitivity value.

7. (D) A is false but R is true.
Precision is the degree of mutual agreement among individual measurements obtained under identical conditions, representing the reproducibility of the system. However, high precision does not guarantee accuracy because systematic errors can cause highly repeatable readings to remain far from the true value. Therefore, a measurement system can be highly precise while being highly inaccurate.

8. (A) Fluctuation in readings due to electronic noise
Random errors are unpredictable variations in measurement results caused by temporary, uncontrollable factors such as thermal noise or electronic fluctuations. These errors manifest as small differences in repeated readings and can be minimized through statistical averaging. In contrast, zero offsets, parallax, and calibration issues represent systematic errors, which are constant or predictable in nature.

9. (B) Range - The maximum rate of change of the output signal
The range of an instrument is defined as the interval between the lower and upper limits of the input physical quantity it is designed to measure. Defining range as the maximum rate of

Click Here to Buy book on Flipkart

change of the output signal is incorrect because that specific characteristic describes the speed of response or slew rate in dynamic systems.

10. (B) Time constant
The time constant is a fundamental parameter of first-order dynamic measurement systems subjected to a step input. It represents the time required for the system response to reach approximately sixty-three point two percent of its final steady-state value. This parameter directly characterizes how quickly a sensor responds to sudden changes in the environment.

11. (C) Second-order system
A second-order measurement system is mathematically modeled by a second-order differential equation, characterized by parameters such as damping ratio and natural frequency. These parameters govern the stability, speed, and oscillatory behavior of the system response when subjected to dynamic inputs, distinguishing them from zero-order and first-order systems which lack these oscillatory traits.

12. (A) Zero-order → First-order → Second-order
Zero-order systems respond instantaneously to input changes without any time lag, making them the fastest dynamic systems. First-order systems exhibit a characteristic time lag dictated by a single energy storage parameter. Second-order systems contain two energy-storing elements, which introduces inertia, potential damping, and slower overall transient settling times during standard dynamic responses to step inputs.

13. (A) I and II
Conductive plastic potentiometers offer essentially infinite resolution due to their smooth, continuous resistive tracks. Wire-wound potentiometers have a finite resolution because the wiper makes discrete contact jumps between adjacent wire turns. Electrical loading effects actually degrade the linearity of the output voltage relative to wiper displacement rather than increasing it, making the third statement incorrect.

14. (C) Change in material resistivity under strain
The piezoresistive effect is the physical phenomenon where the electrical resistivity of a material changes when subjected to mechanical strain. In semiconductor strain gauges, this effect dominates the change in resistance, providing high sensitivity. This differs from metal strain gauges, where resistance changes are primarily caused by changes in length and cross-sectional area.

15. (B) $\dfrac{\frac{\Delta R}{R}}{\frac{\Delta L}{L}}$
The gauge factor is a dimensionless metric of strain gauge sensitivity, defined as the ratio of fractional change in electrical resistance to fractional change in length, or strain. It quantifies how efficiently a mechanical deformation is converted into an electrical resistance change, allowing engineers to calibrate measurement bridges for precise force and displacement calculation.

16. (D) P-3, Q-1, R-2, S-4
Active strain gauges measure mechanical strain directly, while dummy gauges provide temperature compensation without experiencing physical strain. The galvanometer detects small imbalances in bridge current, and the excitation source provides the electrical power necessary for the bridge operation. Matching these elements correctly allows for accurate and temperature-compensated strain measurements in engineering applications.

17. (A) An LVDT has no physical contact between core and coils.
A linear variable differential transformer is an electromagnetic device that measures linear displacement without any mechanical contact between its moving core and stationary coils. This non-contact operation eliminates friction, wear, and mechanical loading, which provides an exceptionally long operating life and infinite resolution compared to sliding-contact resistive potentiometers.

18. (C) Stray capacitance and magnetic imperfections
The residual null voltage in a linear variable differential transformer is the small, non-zero output voltage that remains when the core is at its geometric center. This voltage is primarily caused by stray capacitance between the primary and secondary windings, harmonics in the AC excitation source, and minor magnetic and mechanical asymmetries in the coil structure.

Downloaded from www.pdf.tube

19. (A) Increase non-linearly
The capacitance of a parallel-plate sensor is inversely proportional to the distance between its plates. Consequently, decreasing the air-gap distance causes the capacitance to increase non-linearly. To linearize this response, special operational amplifier circuits or differential configurations are typically employed in practical measurement setups, allowing for accurate displacement sensing over short ranges.

20. (B) I and III
Variable area capacitive sensors maintain a linear relationship between displacement and capacitance. Variable dielectric constant sensors are well-suited for measuring liquid levels as the dielectric changes. However, variable air-gap sensors are highly non-linear over large displacements, and capacitive sensors are passive devices that require an external AC excitation source to operate.

21. (B) Dynamic vibration
Piezoelectric transducers generate electrical charge only in response to active, changing mechanical stresses. Under static or constant conditions, the generated charge leaks away through the internal and external leakage resistance, making them unsuitable for measuring constant forces or static pressures. Therefore, they are primarily used to measure dynamic acceleration, dynamic force, and high-frequency vibration.

22. (C) The total propagation time of the pulse
In an ultrasonic time-of-flight measurement system, the physical distance between the sensor and the target is directly proportional to the total propagation time of the pulse. Since the speed of sound in the medium is constant under fixed conditions, measuring the round-trip travel time of the acoustic wave allows for accurate distance determination.

23. (D) Unequal thermal expansion of bonded metals
Bimetallic thermometers operate on the principle of unequal thermal expansion in two different metals that are bonded together. When subjected to temperature changes, the metal with the higher coefficient of thermal expansion expands or contracts more than the other, causing the strip to bend. This mechanical deflection is then calibrated to indicate temperature.

24. (A) They are highly sensitive and respond faster than thermistors.
Resistance temperature detectors are highly stable and linear, but they are generally less sensitive and have slower response times than thermistors due to their larger thermal mass. Thermistors exhibit massive resistance changes for small temperature shifts. Therefore, asserting that resistance temperature detectors are highly sensitive and respond faster than thermistors is incorrect.

25. (B) Non-linear negative temperature coefficient
Thermistors are semiconductor-based temperature sensors that typically exhibit a highly non-linear negative temperature coefficient of resistance. As temperature increases, their electrical resistance decreases exponentially. This large and sensitive change in resistance over a narrow temperature range makes them excellent for precise temperature monitoring, though they require linearizing circuits for wide-range applications.

26. (B) Law of Intermediate Metals
The Law of Intermediate Metals states that the net electromotive force of a thermocouple circuit is unaltered by the introduction of a third metal, provided that both junctions of this intermediate metal are maintained at the same temperature. This principle allows the connection of measuring instruments, copper leads, and solder junctions without introducing errors.

NODIA

27. (C) A is true but R is false.
Cold junction compensation is critical for accurate thermocouple measurements because these sensors generate a voltage proportional to the temperature difference between the hot and reference junctions. Since they do not measure absolute temperature directly, the reference junction temperature must be compensated. Therefore, the assertion is correct, but the reason is false.

28. (C) Type J
The Type J thermocouple is a widely used temperature sensor consisting of a positive iron wire and a negative constantan wire. This combination is highly suitable for reducing atmospheres but requires protection from oxidation at elevated temperatures. It is distinguished from Type K, which uses chromel

and alumel, and Type T, which uses copper and constantan.

29. (D) Calibrating pressure gauges
Dead-weight testers are primary standards used for the calibration of industrial pressure gauges. They operate by balancing known weights on a piston of a precisely machined cross-sectional area to generate highly accurate static hydraulic pressures within a closed system. This precise reference pressure is compared directly with the reading of the gauge under calibration.

30. (C) Bourdon tube
A Bourdon tube is an elastic pressure-sensing element made of a metal tube flattened into an elliptical cross-section and bent into a C-shape. When internal pressure is applied, the tube tends to straighten, resulting in a displacement of its free end. This movement is mechanically linked to a pointer to display the measured pressure.

31. (C) Between 0.95 and 0.99
The discharge coefficient of a Venturi tube typically ranges between zero point nine five and zero point nine nine. This high value is due to the streamlined design of the converging and diverging cones, which minimizes frictional losses and turbulence. Consequently, the Venturi tube exhibits exceptional pressure recovery compared to other restriction flow meters.

32. (B) I, II, IV and V
Orifice meters produce high permanent pressure loss compared to Venturi tubes due to high turbulence, while flow nozzles resist wear and handle suspended solids better. Venturi tubes are suitable for slurries. Volumetric flow rate is proportional to the square root of pressure drop. Rotameters, however, are constant-pressure-drop, variable-area devices, which makes the third statement incorrect.

33. (A) Variable-area, constant-pressure-drop meter
A rotameter is a variable-area flow meter that operates under a constant pressure drop. As fluid flows upward through a tapered vertical tube, it lifts a float. The float reaches equilibrium when the upward drag and buoyancy forces balance the downward force of gravity, creating a variable annular area directly proportional to the volumetric flow rate.

34. (C) Stagnation pressure and static pressure
Pitot-static tubes determine the velocity of a flowing fluid by measuring the difference between stagnation pressure and static pressure, which represents the dynamic pressure. Stagnation pressure is measured at the forward-facing opening where the fluid is brought to rest, while static pressure is measured through ports parallel to the flow direction, satisfying Bernoulli's equation.

35. (A) I, II, III
The permanent pressure loss in obstruction flow meters is governed by their geometric design. Venturi tubes have the lowest loss due to smooth diverging cones that facilitate pressure recovery. Flow nozzles have moderate loss, while orifice meters have the highest permanent pressure loss because of severe turbulence and flow separation downstream of the sharp-edged constriction.

36. (D) Convective heat transfer
Hot-wire anemometers operate on the principle of convective heat transfer from a heated fine wire exposed to a flowing fluid. As the fluid passes over the wire, it cools it, changing its electrical resistance. By measuring the current or voltage required to maintain wire conditions, the fluid velocity can be accurately determined.

37. (B) Conductive
Electromagnetic flow meters operate on the basis of Faraday's Law of Electromagnetic Induction, which requires the flowing fluid to be electrically conductive. As the conductive fluid flows through a perpendicular magnetic field, it generates a transverse voltage proportional to its average velocity, which is then measured by electrodes mounted on the pipe walls.

38. (C) Directly proportional to fluid velocity
In a vortex shedding flow meter, fluid passing a bluff body generates alternating vortices known as a Von Karman vortex street. The frequency of these shed vortices is directly proportional to the velocity of the fluid over a wide range of Reynolds numbers, providing a highly linear and reliable method for volumetric flow measurement.

39. (D) Well above their natural frequency
Seismic displacement pickups are designed to operate in a frequency range well above their natural frequency. In this region, the relative displacement of the internal proof mass with

Click Here to Buy book on Amazon

respect to the sensor housing is directly proportional to the actual physical displacement of the vibrating structure, allowing for accurate non-contact vibration amplitude measurements.

40. (A) Second-order systems
Piezoelectric accelerometers are mathematically modeled as second-order systems because they consist of an inertial proof mass, a spring-like piezoelectric crystal, and damping components. This mechanical structure obeys second-order differential equations. The accelerometer operates in a frequency range well below its resonant frequency, where the output voltage is directly proportional to the input acceleration.

41. (B) Variable capacitive displacement
MEMS accelerometers frequently utilize variable capacitive displacement mechanisms to detect acceleration. When the device experiences acceleration, an internal silicon proof mass shifts relative to fixed electrodes, altering the electrical capacitance of the structure. This change in capacitance is detected by integrated electronic circuits and converted into a voltage signal proportional to acceleration.

42. (B) Force
Proving rings are high-precision elastic devices primarily used as calibration standards for the measurement of force. When an external force is applied along its diameter, the ring deforms elastically. This small deflection is measured using a sensitive micrometer or transducer, allowing the applied force to be determined with high accuracy.

43. (A) Both A and R are true and R is the correct explanation of A.
Bonded strain gauge load cells are temperature compensated because their Wheatstone bridge circuits incorporate both active and dummy gauges, or use symmetrical bridge arms. Since temperature changes affect all matched gauges equally, the uniform resistance variations cancel out, maintaining a stable bridge balance. Therefore, both statements are true and the reason explains the assertion.

44. (B) 45 degrees
Torque applied to a cylindrical rotating shaft produces principal tensile and compressive strains oriented at forty-five degrees to the longitudinal axis of the shaft. To measure this torsional strain and isolate it from bending or axial loads, strain gauges are mounted at forty-five degree angles to the shaft axis in a bridge configuration.

45. (D) Rotary transformer torque sensor
A rotary transformer torque sensor is ideal for continuous torque measurement on rotating shafts without the wear associated with physical slip rings. It transfers power and signals inductively across a small air gap between a rotating coil on the shaft and a stationary housing coil, providing non-contact, high-speed, and low-maintenance torque sensing.

46. (C) The dielectric constant of a polymer
Capacitive impedance hygrometers measure relative humidity by detecting changes in the dielectric constant of a thin polymer film. As the polymer absorbs water vapor from the surrounding air, its dielectric properties change significantly because water has a high dielectric constant. This alters the overall capacitance, which is directly calibrated to relative humidity.

47. (B) Resonant frequency changes of the crystal
Piezoelectric hygrometers determine moisture content by measuring changes in the resonant frequency of a quartz crystal coated with a hygroscopic substance. As the coating absorbs water vapor, the effective mass of the crystal increases, causing a corresponding decrease in its resonant frequency. This frequency shift is highly measurable and proportional to humidity.

48. (A) I and II
The analytical pH is defined as the negative logarithm of hydrogen ion activity, and the Nernst equation relates the glass electrode potential to this value. However, reference electrodes must maintain a highly stable, constant potential independent of the solution pH to provide a reliable baseline for comparison, making the third statement incorrect.

NODIA

49. (A) An indicator electrode
In a pH measurement system, the glass electrode functions as the indicator electrode because it develops an electrical potential directly proportional to the hydrogen ion activity in the solution. This potential is measured relative to a stable reference electrode, allowing the system to calculate and display the pH value based on the Nernst relationship.

50. (B) 59.16 mV
According to the Nernst equation, at a standard temperature of twenty-five degrees Celsius, a change of one pH unit corresponds to a theoretical change in the indicator glass electrode potential of approximately fifty-nine point one six millivolts. This constant sensitivity coefficient is fundamental for calibrating pH meters in industrial and laboratory applications.

51. (A) T^4
The Stefan-Boltzmann law states that the total radiant exitance of a blackbody is directly proportional to the fourth power of its absolute temperature. This fundamental radiation law governs the total energy emitted across all wavelengths and forms the physical basis for non-contact temperature measurement devices, such as radiation pyrometers and thermal imagers.

52. (D) Decreases
Wien's displacement law states that the wavelength of maximum spectral radiant exitance from a blackbody is inversely proportional to its absolute temperature. As the temperature of the object increases, the peak of its emission spectrum shifts toward shorter wavelengths, representing a decrease in peak wavelength, which shifts from infrared toward visible light.

53. (B) P-4, Q-3, R-2, S-1
Planck's law describes the spectral distribution of blackbody radiation, while the Stefan-Boltzmann law shows that total radiated power is proportional to the fourth power of absolute temperature. Wien's law relates peak wavelength inversely to temperature, and Kirchhoff's law states that emissivity equals absorptivity under thermal equilibrium, forming a complete framework of radiation principles.

54. (C) A calibrated reference lamp filament
Optical pyrometers measure high temperatures by comparing the spectral brightness of the target object with that of a calibrated internal reference lamp filament. The user adjusts the current through the filament until its brightness matches the target, causing the filament to disappear against the background, which correlates directly with the target temperature.

55. (D) They retain position data during power loss.
An absolute position encoder utilizes unique coded patterns for each distinct angular position, allowing it to determine and report the exact shaft position immediately upon power-up without requiring any reference homing movement. This characteristic ensures that position data is retained during power loss, distinguishing it from incremental encoders which lose track of position.

56. (A) Only one bit changes between adjacent positions.
Gray code is highly preferred in digital absolute encoders because only one bit changes state at each transition between adjacent positions. This single-bit transition eliminates transition ambiguity and prevents reading errors that can occur with binary code when multiple bits change simultaneously due to minor mechanical misalignment or electrical propagation delays.

57. (B) Light Source → Optical Disk → Photodetector → Signal Conditioning
In a digital optical encoder, light emitted from a source passes through the patterned tracks of a rotating optical disk. The modulated light is received by a photodetector array, which converts the optical pulses into electrical signals. Finally, signal conditioning electronics process these electrical waveforms into digital outputs representing position or speed.

58. (B) Temperature
Quartz crystal digital thermometers operate on the principle that the resonant frequency of a quartz crystal is highly dependent on its temperature when cut at specific angles. By measuring this frequency change with a high-precision digital counter, temperature can be determined with exceptional resolution and long-term stability, making them excellent reference standards.

59. (A) Acoustic waves on a piezoelectric surface
Surface Acoustic Wave sensors function by converting input electrical signals into high-frequency acoustic waves that propagate across the surface of a piezoelectric substrate. Physical perturbations such as temperature, pressure, or chemical exposure alter the velocity and phase of these acoustic waves, which are then detected and converted back into electrical signals for measurement.

Downloaded from www.pdf.tube

60. (C) Magnetic field
The Hall effect is the generation of a transverse voltage across an electrical conductor or semiconductor when a magnetic field is applied perpendicular to the direction of the current flow. This induced voltage is proportional to the magnetic field strength, making Hall effect sensors highly effective for non-contact magnetic, position, and current sensing.

61. (D) The voltage drop increases linearly with an increase in temperature.
Semiconductor junction thermometers utilize the temperature dependence of a forward-biased p-n junction under constant excitation current. However, the forward voltage drop actually decreases linearly with an increase in temperature, typically at a rate of approximately negative two millivolts per degree Celsius, making the statement that the voltage drop increases incorrect.

62. (C) A is true but R is false.
Photodiodes operate faster when reverse-biased because the external voltage increases the width of the depletion region, which reduces junction capacitance and speeds up carrier collection. This wider depletion region decreases transit time, contrary to the claim that it reduces width. Thus, the assertion is true, but the reasoning provided is false.

63. (B) Internal amplification of the photocurrent
A phototransistor operates similarly to a photodiode but provides internal amplification of the photocurrent. When light generates charge carriers in the base-collector junction, the resulting base current is amplified by the transistor gain, producing a much larger output current. However, this amplification comes at the cost of a slower response time compared to photodiodes.

64. (D) Shifting photo-generated charge packets for readout
Charge-Couled Devices operate by accumulating photo-generated electrical charges within potential wells at individual pixel locations when exposed to light. These stored charge packets are then shifted sequentially across the array to a common output amplifier for readout. This analog shift register mechanism is fundamental to capturing high-resolution digital images.

65. (A) Rotameter - Temperature measurement
A rotameter is a variable-area flow meter designed specifically to measure the volumetric flow rate of liquids or gases, not temperature. This mismatch makes its pairing with temperature measurement incorrect, whereas linear variable differential transformers measure displacement, load cells measure force, and bellows measure mechanical pressure through elastic structural deflection.

66. (A) I, II and IV
Systematic errors are predictable and can be corrected through calibration, while random errors follow normal statistical distributions and require statistical averaging. Uncertainty analysis defines the estimated bounds of overall error. Zero error is a constant offset and is classified as a systematic error rather than a random error, making the third statement incorrect.

NODIA

67. (A) Drift
Drift is the gradual, unwanted change in the output of a sensor over time when the input physical variable remains completely constant. It is typically caused by environmental changes such as temperature fluctuations, aging of internal electronic components, or mechanical relaxation, and it can affect the overall accuracy and calibration of the instrument.

68. (D) It slows the response without overshoot.
Increasing the damping ratio of a second-order system above one point zero creates an overdamped system. This increased damping slows down the dynamic response because of the high resistance to motion, but it prevents any overshoot or oscillatory behavior during a step transition, resulting in a smooth and stable approach to the final steady-state value.

69. (B) P-1, Q-2, R-4, S-3
The time constant determines the speed of response in first-order systems, while natural frequency governs the oscillation rate of second-order systems. The phase shift represents the delay between sinusoidal inputs and outputs, and the damping ratio controls overshoot and decay rates in dynamic systems, providing a complete characterization of system performance.

70. (C) Time constant times the ramp rate
When a first-order dynamic measurement system is subjected to a steady ramp input, the

steady-state dynamic error becomes constant after transient effects decay. This steady-state error is mathematically equal to the product of the system time constant and the input ramp rate, representing the constant lag of the output behind the input.

71. (D) Finite resolution from wire turns
The principal disadvantage of wire-wound potentiometers is their finite resolution, which is limited by the physical distance between adjacent turns of the resistance wire. As the wiper moves along the coil, the output voltage changes in discrete steps rather than continuously, which introduces measurement noise and limits their use in high-precision applications.

72. (A) Complex strains when directions are unknown
Rosette strain gauges consist of three or more closely spaced independent strain gauges oriented at specific angles relative to each other. They are used to determine complex, multi-axial strain fields on a surface when the directions of the principal stresses are unknown, allowing engineers to calculate principal strains through coordinate transformation equations.

73. (B) The same temperature but no mechanical strain
A dummy strain gauge in a Wheatstone bridge is mounted on the same material and kept under the identical temperature conditions as the active gauge, but it is isolated from physical mechanical strain. This arrangement ensures that temperature-induced resistance changes affect both gauges equally, allowing the bridge circuit to cancel out temperature errors.

74. (B) I and III
A linear variable differential transformer produces an AC output voltage whose phase shifts by one hundred and eighty degrees as the core passes through the null position. It requires AC voltage excitation and possesses infinite theoretical resolution due to its electromagnetic, non-contact design, making the second statement regarding DC excitation incorrect.

75. (A) The dielectric constant
A capacitive level sensor in a non-conductive tank measures liquid height by utilizing the difference in dielectric constant between the liquid and the air. As the liquid level changes, the volume of liquid between the electrodes changes, altering the effective dielectric constant and capacitance of the system in a highly linear manner.

76. (C) Induced charge to applied mechanical stress
In piezoelectric materials, the piezoelectric charge coefficient relates the magnitude of the generated electrical charge on the crystal faces to the applied mechanical stress. This coefficient is a key parameter that determines the sensitivity of piezoelectric sensors when converting physical force, pressure, or acceleration into a measurable electrical charge signal.

77. (D) Eliminate the effect of cable capacitance
Charge amplifiers are preferred for piezoelectric sensors because they convert the high-impedance charge signal into a low-impedance voltage while keeping the sensor cable under virtual ground. This configuration eliminates the signal attenuation and sensitivity variations that would otherwise be caused by the capacitance of the connecting cable, ensuring stable calibration.

78. (C) Pulse Generator → Transducer → Propagation Medium → Receiver → Timer
In a time-of-flight ultrasonic system, the pulse generator triggers the transmitting transducer to emit acoustic waves. These waves travel through the physical propagation medium and are detected by the receiver. A high-precision timer measures the interval between the initial pulse generation and the wave arrival, allowing the system to calculate distance.

79. (A) Both A and R are true and R is the correct explanation of A.
Resistance temperature detectors are passive transducers because they do not generate an electrical signal on their own and require an external current source to measure resistance. Since their resistance changes with temperature, forcing a current through them allows this variation to be measured as a voltage. Thus, both statements are true and related.

80. (D) A single conductor with a temperature gradient
The Thomson effect is the absorption or evolution of heat that occurs when an electric current flows through a single conductor that possesses a temperature gradient along its length. This reversible thermal phenomenon depends on both the direction of the current and the sign of the

Click Here to Buy book on Flipkart

temperature gradient, complementing Seebeck and Peltier effects.

81. (A) Using a terminal block temperature sensor
Modern digital temperature measurement systems achieve cold junction compensation by placing a separate temperature sensor, such as a thermistor or semiconductor sensor, on the thermocouple terminal block. This sensor measures the actual temperature of the reference junction, allowing the system microprocessor to calculate and add the appropriate correction voltage mathematically.

82. (C) Isolates the medium from the sensor via deflection.
A key characteristic of diaphragm pressure sensors is their ability to isolate the process fluid or medium from the sensitive measurement elements. The flexible diaphragm deflects in response to applied pressure, transmitting this physical motion to strain gauges or capacitive plates on the dry side, preventing contamination or corrosion of the sensor.

83. (A) The point of minimum area and lowest pressure
The vena contracta in an orifice meter is the location downstream of the physical restriction where the fluid jet achieves its minimum cross-sectional area. At this point, the fluid velocity is at its maximum and the static pressure is at its lowest, creating the differential pressure measured for flow rate calculations.

84. (D) P-2, Q-4, R-1, S-3
Venturi tubes operate on Bernoulli's principle of differential pressure, while rotameters balance the upward drag force against gravity. Electromagnetic meters utilize Faraday's Law of Induction, and hot-wire anemometers relate fluid velocity to convective heat transfer rates from a heated wire, establishing a correct mapping between these common flow measurement devices.

85. (B) Upstream and downstream transit-time difference
Transit-time ultrasonic flow meters determine fluid velocity by measuring the small difference in propagation times between acoustic pulses transmitted upstream against the flow and downstream with the flow. Because the fluid velocity accelerates or retards the sound waves, this time difference is directly proportional to the average velocity of the fluid.

86. (C) Viscous or particulate-laden flows
Pitot-static tubes are highly sensitive to blockage and are poorly suited for viscous, dirty, or particulate-laden fluid flows because suspended solids can easily clog the small stagnation and static pressure ports. This clogging disrupts pressure transmission and leads to highly inaccurate velocity measurements, making them ideal only for clean gases or liquids.

NODIA

87. (D) Conservation of angular momentum
A gyroscopic angular sensor operates fundamentally on the principle of the conservation of angular momentum. When a spinning rotor or vibrating structure experiences an angular rotation, it generates a gyroscopic torque or Coriolis force proportional to the rate of rotation. This force is detected and converted into an electrical signal indicating angular velocity.

88. (A) I and III
MEMS sensors integrate mechanical structures, sensors, actuators, and electronic circuits on a common silicon substrate using microfabrication technology. They heavily utilize high-precision capacitive or piezoresistive sensing mechanisms. They are much smaller than traditional sensors and are highly capable of measuring dynamic accelerations, making the second and fourth statements incorrect.

89. (B) Inductance by altering the magnetic air gap
A variable reluctance force sensor measures mechanical force by translating applied stress into a small physical displacement of a ferromagnetic core. This movement alters the size of the magnetic air gap within a magnetic circuit, directly changing the reluctance and the self-inductance of the sensing coil, which is measured electrically.

90. (B) Transfer signals between rotating and stationary parts
When measuring torque on rotating shafts, slip rings are used to establish a continuous electrical connection between the moving strain gauges on the shaft and the stationary measurement instruments. They consist of rotating metal rings in physical contact with stationary conductive

brushes, allowing excitation power and low-level bridge signals to pass safely.

91. (A) The air becomes saturated and condensation begins
The dew point is the temperature to which air must be cooled, at constant barometric pressure, for water vapor to condense into liquid water. At this temperature, the air is fully saturated with moisture, and the relative humidity reaches one hundred percent, providing a fundamental thermodynamic reference point for humidity measurement.

92. (D) A is false but R is true.
Ion-selective electrodes operate by establishing a potential difference across a selective membrane through ion-exchange processes. However, they are not completely immune to interference from other ions of similar charge or size, meaning they are highly selective rather than exclusively sensitive to a single species. Therefore, the assertion is false, but the reason is true.

93. (D) Altering physical properties via temperature change
In a thermal radiation detector, the sensing element absorbs incident electromagnetic radiation, which causes its temperature to rise. This temperature increase alters a physical property of the detector material, such as electrical resistance in bolometers, thermoelectric voltage in thermopiles, or polarization in pyroelectric sensors, allowing the radiation intensity to be measured.

94. (C) Respond directly to photon-excited electrons
Photon detectors differ from thermal detectors by interacting directly with individual incident photons to excite electrons into higher energy bands, producing a measurable electrical current or voltage. This quantum detection mechanism provides extremely fast response times and high sensitivity, although its spectral response is non-uniform and depends heavily on photon energy.

95. (B) Provide a reference index once per revolution
Incremental digital encoders include a Z or index channel that outputs a single electrical pulse for each complete revolution of the encoder disk. This pulse establishes a precise, absolute physical reference position used to reset position counters, synchronize motion control systems, and detect errors in the standard incremental pulse counts.

96. (D) Moiré fringe formation
Optical gratings in high-resolution linear encoders utilize the physical phenomenon of Moiré fringe formation. When two gratings with slightly different line spacings or orientations are overlaid, they produce a pattern of light and dark fringes that shift significantly for very small physical movements, allowing photodetectors to measure sub-micron displacements accurately.

97. (C) I and II
Quartz crystal digital thermometers utilize the fundamental piezoelectric properties of quartz and feature a highly linear relationship between their resonant frequency and temperature. They offer exceptional measurement accuracy and long-term stability that easily surpasses standard K-type thermocouples, meaning the third statement regarding their lower relative accuracy is completely incorrect.

NODIA

98. (C) Carrier deflection altering recombination rate
The primary mechanism of a magneto-diode is the magnetic deflection of injected charge carriers by the Lorentz force, which alters their recombination rate within the semiconductor material. This change in carrier density significantly modifies the forward current-voltage characteristics of the diode, providing a highly sensitive means of detecting external magnetic fields.

99. (A) P-1, Q-3, R-2, S-4
Hall effect sensors rely on the Lorentz force on charge carriers, while semiconductor junction thermometers exploit the temperature dependence of forward voltage. Photodiodes generate active charge carriers through photon absorption, and magneto-resistors experience a change in resistance in a magnetic field, establishing a correct mapping between these semiconductor sensing devices.

100. (D) Bucket brigade
In a charge-coupled device imaging sensor, the movement of photo-generated charge packets from one potential well to the next is highly analogous to a bucket brigade. Charges are transferred step-by-step through successive potential wells toward an output amplifier,

ensuring that spatial image details are preserved during the sequential readout process.

101. (B) Friction, magnetic saturation, or elastic lags
The phenomenon of hysteresis in a measurement instrument is most commonly caused by internal friction between mechanical components, magnetic saturation in core materials, or elastic lags in spring structures. These factors cause the output of the instrument to differ depending on whether the input is increasing or decreasing, creating a characteristic loop.

102. (A) Calculate Mean → Calculate Standard Deviation → Identify Outliers → Determine Confidence Interval
The correct statistical evaluation sequence begins by calculating the mean to find the central tendency, followed by computing the standard deviation to assess data dispersion. Next, outliers are identified and removed to prevent skewing the results, and finally, the confidence interval is determined to define the statistical bounds of the measured values.

103. (A) 0.2 °C
To find the temperature resolution, the digital display resolution of one millivolt is divided by the sensor sensitivity of five millivolts per degree Celsius. This calculation yields a temperature resolution of zero point two degrees Celsius, representing the smallest change in physical temperature that can be resolved on the digital display.

104. (A) Closeness of the reading to the true value
Accuracy is defined as the closeness of agreement between a measured value and the true or accepted reference value of the physical quantity. It characterizes the total error of the system, including both systematic and random components, distinguishing it from precision, which refers only to the repeatability of the readings.

105. (A) I, II and IV
Precision does not guarantee high accuracy due to systematic errors, and uncertainty analysis estimates error bounds rather than finding the exact true value. Furthermore, systematic errors cannot be reduced by simple averaging because they remain constant across repeated measurements, which means the first, second, and fourth statements are indeed incorrect.

106. (C) 95.0%
A first-order dynamic measurement system subjected to a step input reaches approximately ninety-five percent of its final steady-state value after a time duration equal to three time constants. For a system with a time constant of two seconds, three time constants equal six seconds, resulting in this specific level of response.

107. (A) Both A and R are true and R is the correct explanation of A.
A second-order system will exhibit oscillatory behavior when its damping ratio is less than one point zero, which is the underdamped condition. In this regime, the characteristic equation contains complex conjugate roots, leading to a sinusoidal output that decays exponentially over time. Therefore, both statements are true and the reason explains the assertion.

108. (A) Zero
A zero-order measurement system responds instantaneously and perfectly to any input signal without any time lag or energy storage. Consequently, when subjected to a purely sinusoidal input of any frequency, its output tracks the input with zero dynamic error and zero phase shift, representing an completely ideal dynamic response.

109. (C) The total number of turns of the resistance wire
The theoretical resolution limit of a wire-wound potentiometer is determined solely by the total number of turns of the resistance wire. Because the wiper moves from one discrete wire turn to the next, the output voltage changes in steps, and this step size defines the resolution limit of the device.

110. (D) Its piezoresistive effect is temperature-dependent.
Temperature compensation is highly critical in semiconductor strain gauges because their piezoresistive effect, which determines their high sensitivity, is heavily dependent on ambient temperature. Temperature changes cause significant drift in both the gauge resistance and the gauge factor, necessitating active external compensation to maintain overall measurement accuracy.

Downloaded from www.pdf.tube

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

111. (C) Four active gauges with two in tension and two in compression
To maximize the output sensitivity of a Wheatstone bridge measuring strain, a full bridge configuration with four active gauges is used. Two gauges are mounted to experience tension while the other two experience compression. This arrangement maximizes the bridge imbalance for a given strain, resulting in the highest possible sensitivity.

112. (B) P-4, Q-2, R-1, S-3
A linear variable differential transformer relies on mutual electromagnetic induction, while conductive plastic potentiometers provide infinite resolution through continuous contact. Variable gap capacitive sensors exhibit a non-linear relationship over large ranges, and optical encoders output digital pulse trains, providing a correct and systematic pairing of these displacement sensors.

113. (D) Excitation harmonics and stray capacitance
A linear variable differential transformer exhibits a small residual null voltage at its central position due to excitation harmonics in the AC power supply and stray electrical capacitance between the windings. Additionally, minor mechanical and magnetic asymmetries in the coils prevent the secondary voltages from canceling out perfectly at the null point.

114. (A) Capacitance varies linearly with overlapping area
In capacitive variable-area sensors, the electrical capacitance is directly proportional to the overlapping area of the plates. This relationship yields a highly linear output with respect to displacement, making these sensors ideal for measuring relatively large linear or angular movements without the severe non-linearities common to variable air-gap sensors.

115. (A) II, III and IV
Piezoelectric sensors act as charge generators and are ideal for shock and vibration measurements, utilizing materials such as quartz or barium titanate. However, they cannot measure true static inputs indefinitely due to charge leakage, and their charge sensitivity is temperature-dependent, making the first and fifth statements completely incorrect.

116. (B) The distance reading decreases because the wave travels faster, resulting in a shorter transit time.
An increase in ambient air temperature increases the speed of sound in air. For a fixed target, the higher acoustic velocity causes the ultrasonic pulse to travel faster, resulting in a shorter round-trip transit time. Consequently, the uncompensated measurement system interprets this shorter transit time as a smaller measured distance.

NODIA

117. (D) Their coefficients of thermal expansion differ.
Bimetallic strips consist of two dissimilar metal layers bonded together. When subjected to a temperature change, the metals expand or contract at different rates because of their differing coefficients of thermal expansion. This unequal expansion creates internal mechanical stresses that force the bonded strip to bend toward the metal with the lower coefficient.

118. (B) Platinum
Platinum is widely preferred as the sensing material for high-precision resistance temperature detectors because it provides a highly stable, reproducible, and linear resistance-temperature relationship over a very wide temperature range. It is chemically inert and highly resistant to oxidation, making it the absolute industry standard for temperature calibration.

119. (C) Sintered metal oxide mixtures
Thermistors are manufactured primarily from sintered mixtures of transition metal oxides such as manganese, nickel, cobalt, and copper. These semiconductor materials exhibit a highly sensitive temperature dependent electrical resistance. This manufacturing process allows them to be formed into small beads, disks, or probes with extremely high negative temperature coefficients for precise measurements.

120. (A) Both A and R are true and R is the correct explanation of A.
The Peltier effect is the direct thermodynamic reverse of the Seebeck effect. It describes the absorption or emission of thermal energy at an electrical junction of two dissimilar conductors when an external current is forced through the circuit. Therefore, both the assertion and reason are true, and the reason correctly explains the assertion.

121. (A) Chromel and Alumel
The Type K thermocouple is a standard and highly popular temperature sensor that consists of a positive wire made of Chromel, which is a nickel-chromium alloy, and a negative wire made of Alumel, which is a nickel-aluminum alloy. This combination is highly suitable for oxidizing atmospheres over a wide temperature range.

122. (B) The hydrostatic head of a liquid column
Manometers measure pressure by balancing the force exerted by the applied pressure against the hydrostatic head of a liquid column of known density. The difference in the liquid level heights between the two columns is directly proportional to the pressure difference, providing a simple, highly accurate, and fundamental calibration standard.

123. (A) I, II, III
Bellows are highly sensitive and suited for low-pressure ranges due to their large displacements. Diaphragms offer moderate stiffness and are suitable for medium-pressure ranges. Heavy-walled Bourdon tubes are highly stiff and designed specifically for extremely high-pressure hydraulic applications, establishing the correct sequence from lowest to highest pressure ranges.

124. (A) Pascal's law and weights on a known piston area
The operation of a dead-weight tester is based on Pascal's law, where pressure is generated by applying calibrated weights onto a piston of a precisely machined cross-sectional area. By balancing the downward gravitational force of the weights against the upward hydraulic pressure, a highly accurate and stable reference pressure is generated.

125. (C) P-4, Q-3, R-1, S-2
Orifice plates produce the highest permanent pressure loss, while Venturi tubes have the lowest loss due to their streamlined shape. Rotameters operate as variable-area meters, and pitot tubes provide point velocity measurements. Matching these characteristics with their correct flow meter names establishes a systematic framework for choosing appropriate industrial flow instrumentation.

126. (D) Magnetic flow meter
A magnetic flow meter measures volumetric flow rate without introducing any physical obstruction or pressure drop into the pipeline. It operates by generating a magnetic field across a non-magnetic pipe section, inducing a voltage in the conductive fluid that is directly proportional to velocity, leaving the flow path completely unobstructed.

127. (D) I, II and III
Hot-wire anemometers are widely used for gas velocity measurements, operating in either constant current or constant temperature modes. Constant temperature anemometry is highly preferred for measuring turbulent flows due to its extremely fast response times. This rapid dynamic response makes all three statements regarding their applications and operation correct.

128. (B) Reflective gas bubbles or suspended particles
Doppler ultrasonic flow meters require the flowing fluid to contain acoustic reflectors, such as suspended solid particles or small entrained gas bubbles. The ultrasonic wave transmitted into the pipe reflects off these moving particles, producing a frequency shift directly proportional to the fluid velocity according to the Doppler effect.

129. (D) Displacement pickups
Seismic vibration sensors designed to operate at frequencies well above their natural frequency function as displacement pickups. In this high-frequency region, the internal proof mass remains essentially stationary in space, and the relative motion between the mass and the housing is directly proportional to the displacement of the vibrating structure.

130. (A) It can measure static (DC) accelerations like gravity.
A key advantage of MEMS accelerometers over conventional piezoelectric accelerometers is their ability to measure static or constant accelerations, such as gravity. Piezoelectric accelerometers rely on dynamic stress to generate charge, which quickly dissipates, making them unable to measure static inputs, whereas MEMS capacitive designs can detect constant tilts easily.

131. (C) Inertia of an internal proof mass
In a piezoelectric accelerometer, the mechanical force exerted on the piezoelectric crystal is generated by the inertia of an internal proof mass. When the sensor is accelerated, the proof

Click Here to Buy book on Amazon

mass exerts a force on the crystal proportional to the acceleration, producing an electrical charge proportional to the input motion.

132. (C) A is true but R is false.
Optical pyrometers can measure temperatures of targets inside vacuum chambers through glass windows because radiant energy passes through the vacuum. However, the glass window actually absorbs and reflects a small portion of the radiant energy, requiring correction factors. Therefore, the assertion is correct, but the reasoning provided is false.

133. (D) Proving ring
The proving ring is a high-precision force-sensing device that relies on the elastic deformation of a machined steel ring. When a tensile or compressive force is applied along its diameter, the ring deforms, and this small mechanical deflection is measured with a high-accuracy dial indicator or an integrated transducer.

134. (B) Magnetic reluctance via an air gap
Variable reluctance sensors measure force by converting applied stress into a small physical displacement of a ferromagnetic armature. This movement directly alters the width of the magnetic air gap, which changes the magnetic reluctance of the circuit and varies the inductance of the coils, generating a measurable electrical signal.

135. (C) Phase shift between two shaft-mounted wheels
Torque measurement on rotating shafts using optical methods relies on measuring the phase shift between two slotted wheels mounted at different positions along the shaft. When torque is applied, the shaft twists elastically, creating an angular displacement and a corresponding optical phase shift that is directly proportional to torque.

136. (C) A moisture-sensitive polymer dielectric
Capacitive hygrometers measure relative humidity by detecting changes in the capacitance of a thin polymer film. This moisture-sensitive polymer dielectric absorbs or releases water vapor from the surrounding environment. As moisture absorption occurs, the dielectric constant of the polymer layer alters proportionally, which directly shifts the measured electrical capacitance of the sensor.

137. (D) Measuring the attenuation of ionizing gamma rays
Direct gas density measurement is frequently performed using radiation absorption principles. When ionizing gamma rays pass through a gas sample, the degree of radiation attenuation depends directly on the mass of the gas molecules in the path. Measuring this attenuation rate provides an accurate, non-contact determination of the absolute density of the gas.

138. (D) Increased by a factor of 100
The pH scale is logarithmic, meaning each unit change corresponds to a tenfold change in hydrogen ion concentration. A drop in pH from seven to five represents a decrease of two pH units. Because pH is defined as the negative logarithm of hydrogen ion activity, this shift indicates that the concentration has increased by ten squared.

139. (A) P-2, Q-1, R-3, S-4
In electrochemical analysis, glass electrodes produce a variable electrical potential depending on the hydrogen ion activity. A reference electrode provides a stable baseline potential against which this variation is measured. The Nernst equation mathematically relates the electrical potential to ion activity, while ion-selective membranes filter and permit specific target ions for detection.

140. (B) Alkali error at high pH levels
Glass pH electrodes exhibit a measurement discrepancy known as alkali or sodium error under highly alkaline conditions, typically above ten pH. In these basic solutions, the glass membrane starts responding to alkali metal ions, such as sodium, instead of hydrogen ions alone. This leads to an incorrectly low reading of the actual pH.

NODIA

141. (A) Spectral distribution of blackbody radiation
Planck's radiation law is a fundamental principle of physics that characterizes how electromagnetic radiation is distributed over different wavelengths. It establishes the quantitative relationship between the spectral radiance of a blackbody and its thermodynamic temperature, demonstrating that the energy emission of an idealized blackbody is continuous but peaks at a temperature-dependent wavelength.

142. (A) Incremental Single-Channel → Incremental Quadrature → Binary Absolute → Gray Code Absolute
Digital position encoding scales in complexity from simple incremental single-channel systems to advanced absolute architectures. Single-channel encoders only count pulses, whereas quadrature encoders add a second channel to detect direction. Absolute binary encoders offer unique position patterns but risk multi-bit errors, which are resolved by Gray code where only one bit changes at once.

143. (D) Discriminate the direction of movement
Quadrature incremental encoders employ two distinct detection tracks offset by ninety electrical degrees. This spatial phase separation creates two output square-wave signals, traditionally designated as A and B, which are out of phase. By evaluating which signal leads or lags, the receiver can determine the clockwise or counterclockwise direction of rotational or linear displacement.

144. (A) Both A and R are true and R is the correct explanation of A.
Absolute encoders retain their precise position information even during sudden power losses. This is because their construction features disk patterns that represent a unique physical binary code for each specific angle. Unlike incremental variants that count relative pulses and require homing, absolute models read the unique, hardcoded physical layout directly upon startup.

145. (B) An interrogating RF pulse excites an acoustic wave, reflecting an echo.
Surface Acoustic Wave sensors are ideal for passive, wireless operation because they do not require an internal power source. An external radio-frequency antenna transmits an interrogation signal to the sensor. The piezoelectric substrate converts this electrical energy into an acoustic wave, which travels, encounters reflective gratings, and returns as a modified radio-frequency echo.

146. (B) I, II and III
Hall effect sensors respond to both static and dynamic magnetic fields. They require a steady excitation current to generate the transverse Hall voltage, which is directly proportional to the perpendicular magnetic flux density. Due to this reliable relationship, they are widely used for non-contact proximity switching and rotational speed detection applications.

147. (A) Providing built-in signal amplification
Standard Hall elements output a very weak analog voltage that is highly susceptible to external noise and requires external amplification. A magneto-transistor integrates the magnetic-field-sensitive collector current modulation directly into a transistor structure. This configuration provides internal, high-gain signal amplification, producing a significantly larger and more robust output signal for processing.

148. (C) Produce a light-proportional current with minimal dark current noise
Operating a photodiode in photovoltaic mode involves keeping the bias voltage across the junction at zero. In this operating state, the dark current is extremely small, which leads to minimal background thermal noise. This makes the zero-bias configuration highly suitable for precise measurements of low light levels, generating a highly linear, light-proportional current.

149. (A) MOS capacitors storing photo-generated charge
Charge-Coupled Devices rely fundamentally on an array of Metal-Oxide-Semiconductor capacitors fabricated on a silicon substrate. Incident photons generate electron-hole pairs within the semiconductor, and the resulting charge is collected and stored within potential wells under each capacitor. These stored charge packets are then sequentially shifted across the chip to a single amplifier for readout.

150. (D) A high-voltage power supply
Photomultiplier tubes require a high-voltage power supply, typically ranging from hundreds to thousands of volts, to function correctly. This high voltage is necessary to establish the strong electrostatic fields between the successive internal dynodes. These fields accelerate photoelectrons, driving secondary electron emission and achieving the massive signal amplification that defines photomultiplier tubes.

151. (B) Dependence of acoustic impedance on fluid density
Ultrasonic densitometers determine the density of a fluid by measuring how acoustic waves interact with it. The fundamental principle

Downloaded from www.pdf.tube

is that the acoustic impedance of a medium depends directly on both its density and the speed of sound within it. By measuring wave reflections at boundaries, the fluid's density is calculated.

152. (A) P-3, Q-1, R-4, S-2
Different optical sensors possess distinct performance traits. Photomultiplier tubes offer extreme sensitivity through secondary emission. Reverse-biased photodiodes operate at very high speeds but have no internal gain. Phototransistors provide moderate operating speeds with built-in current amplification. Charge-Coupled Devices collect and transfer photo-generated charges to capture complex two-dimensional light patterns and images.

153. (D) A consistent offset or proportional deviation
Systematic errors are reproducible discrepancies that consistently bias measurements in one direction. In a transducer calibration curve, this behavior is visible either as a constant zero offset, where the curve shifts vertically from the true line, or as a proportional deviation, where the slope of the calibration curve differs from the ideal value.

154. (A) $\sqrt{\left(\frac{u_x}{x}\right)^2+\left(\frac{u_y}{y}\right)^2}$
When calculating the propagation of independent random errors for multiplicative relationships, the relative uncertainties must be combined. The square of the fractional uncertainty of the final result is equal to the sum of the squares of the individual fractional uncertainties. Taking the square root yields the standard root-sum-square formula for relative uncertainty.

155. (D) A is false but R is true.
Increasing the gain of an amplifier does not improve the signal-to-noise ratio. A linear amplifier scales both the input signal and the input noise by the same factor, leaving the ratio unchanged. Additionally, the amplifier itself introduces internal electronic thermal noise, which actually degrades the final signal-to-noise ratio of the system.

156. (B) Undamped
In dynamic system analysis, the damping ratio indicates how oscillations decay after a disturbance. When this ratio is exactly zero, the system possesses no internal energy dissipation or friction. Consequently, the system is undamped and will oscillate indefinitely at its natural frequency with a constant amplitude when subjected to a step input.

157. (A) A high-quality linear resistive potentiometer
A zero-order system is one whose output instantaneously tracks any changes in the input without dynamic lag. A high-quality linear resistive potentiometer approximates this behavior because its electrical resistance output changes immediately as the physical wiper slides across the track, exhibiting negligible inertial mass or thermal delay under normal operating conditions.

158. (C) Significant loading current drawn by the output meter
Electrical loading in a potentiometer occurs when the output measuring instrument has a finite input impedance instead of an ideal infinite impedance. This causes a significant current to be drawn through the wiper arm. Consequently, the relationship between the mechanical displacement and the output voltage becomes non-linear, introducing a measurement error.

NODIA

159. (A) I and III
Metal foil strain gauges offer superior heat dissipation compared to wire types because of their larger flat surface area. Semiconductor strain gauges exhibit exceptionally high sensitivity, with gauge factors often exceeding a hundred, which is much greater than metallic gauges. However, transverse sensitivity is an undesirable trait, and mechanical creep remains a potential issue.

160. (C) An identical gauge on an unstrained block at the same temperature.
Temperature changes cause thermal expansion and resistance shifts in active strain gauges, creating false strain readings. To compensate, an identical dummy gauge is mounted on an unstrained reference block of the same material. Placing this block in the same thermal environment allows temperature-induced resistance changes to cancel out within a Wheatstone bridge circuit.

161. (B) LVDT measures linear displacement, RVDT measures rotary.
The core difference between these two inductive sensors lies in their mechanical measurement capabilities. A Linear Variable Differential

Transformer measures straight-line linear displacement along its axis. A Rotary Variable Differential Transformer utilizes a specially shaped, rotating ferromagnetic core to measure angular or rotational displacement over a specified angular range.

162. (A) AC Excitation → Core Displacement → Differential AC Output → Phase-Sensitive Demodulation → DC Output
The operation of an LVDT begins with AC excitation applied to the primary coil. Physical movement of the ferromagnetic core alters magnetic coupling, generating a differential AC voltage across the secondary coils. This AC output is processed by a phase-sensitive demodulator to determine displacement direction, producing a final scaled DC output signal.

163. (A) Determine the direction of core displacement
An LVDT's raw differential AC output voltage magnitude is identical for equal displacements on either side of the null position. However, the phase of the output voltage shifts by one hundred eighty degrees when the core crosses the center. A phase-sensitive demodulator compares this phase against the primary AC reference to determine the direction of displacement.

164. (A) P-2, Q-4, R-1, S-3
Thermocouples operate on the Seebeck effect to generate a voltage from temperature gradients. Resistance Temperature Detectors measure the resistance of pure metals like platinum. Thermistors rely on metal oxide semiconductor materials that exhibit high resistance changes with temperature, while bimetallic strips utilize the differential thermal expansion of two joined metals to produce physical movement.

165. (A) It necessitates that the intermediate temperature T_2 must be physically applied to an external junction.
The Law of Intermediate Temperatures mathematically allows thermocouple calibration data to be adjusted between different reference temperatures. It states that the total electromotive force generated between two temperatures equals the sum of the potentials over intermediate steps. It does not require an intermediate temperature to be physically established at an actual junction during system operation.

166. (A) Both A and R are true and R is the correct explanation of A.
Elastic pressure sensors like Bourdon tubes suffer from hysteresis, meaning their output values differ depending on whether pressure is rising or falling. This occurs because physical materials are never perfectly elastic. Internal molecular friction and structural memory retain tiny deformations during loading cycles, preventing the material from returning instantly to its exact original shape.

167. (B) Dead-weight tester
A dead-weight tester is a primary calibration standard because it derives pressure directly from fundamental physical quantities: force and area. It applies a known mass over a piston of precisely machined cross-sectional area. Since pressure equals force divided by area, it generates a highly accurate, reproducible pressure reference without needing comparison to another gauge.

168. (C) An inclined tube manometer
Measuring very low differential pressures requires an instrument with high sensitivity. An inclined tube manometer achieves this by tilting the indicating column at an angle. This design amplifies the physical liquid displacement along the tube for a given pressure change, allowing small pressure variations to be read easily and accurately on a graduated scale.

169. (D) The region of minimum flow cross-sectional area
When a fluid passes through a sharp-edged orifice plate, the streamlines cannot make abrupt turns. Consequently, the flow continues to converge for a short distance downstream of the physical restriction. The spatial location where the jet achieves its minimum cross-sectional area and maximum velocity is designated as the vena contracta.

170. (A) Coriolis flow meter
A Coriolis flow meter directly measures the true mass flow rate of a fluid. It works by vibrating the internal flow tubes. As fluid passes through, it induces a Coriolis force that twists the vibrating tubes. The resulting phase shift between sensor points is directly proportional to mass flow, independent of temperature or density.

Click Here to Buy book on Flipkart

171. (A) I, III and V
Variable-head flow meters utilize physical obstructions to create a local velocity change, resulting in a measurable differential pressure drop. Venturi tubes, orifice plates, and flow nozzles are classic examples of these obstruction-type meters. They require differential pressure transmitters to calculate the flow rate based on Bernoulli's theorem, unlike electromagnetic meters or rotameters.

172. (B) The ratio of maximum to minimum measurable flow
The turn-down ratio, also called the rangeability of a flow meter, defines the operational span over which the instrument can measure flow within its specified accuracy limits. It is mathematically calculated as the ratio of the maximum design flow rate to the minimum detectable and accurate flow rate that the sensor can handle.

173. (A) Provides a much higher frequency response
Constant Temperature Anemometer systems maintain the active sensing wire at a constant temperature using a high-speed feedback bridge circuit. Because the wire's thermal state remains constant, the thermal inertia of the wire is effectively bypassed. This allows the system to achieve a significantly higher frequency response, making it suitable for measuring rapid turbulence.

174. (C) Fluid velocity
Electromagnetic flow meters operate on Faraday's Law of Electromagnetic Induction. When a conductive fluid moves through a magnetic field perpendicular to its flow direction, an electromotive force is induced. This induced voltage is directly proportional to the average velocity of the fluid, the strength of the magnetic field, and the distance between the measurement electrodes.

175. (A) P-2, Q-4, R-3, S-1
Vibration and motion sensors use distinct operational mechanisms. Seismic displacement pickups require a soft spring for low natural frequencies to isolate movement. Piezoelectric accelerometers are self-generating but cannot measure steady DC acceleration. MEMS piezoresistive accelerometers effectively measure DC and static acceleration, while gyroscopes are designed to measure the angular velocity of an object.

176. (C) A vibratory MEMS gyroscope
Modern electronic devices measure rotational velocity using vibratory MEMS gyroscopes. These solid-state sensors contain no rotating mechanical parts. Instead, they utilize tiny vibrating elements that experience a Coriolis force when rotated. This force causes a secondary vibration perpendicular to the initial drive motion, which is capacitive sensed to determine the angular velocity.

177. (D) A is false but R is true.
Piezoelectric sensors are preferred for high-frequency dynamic force measurements over strain gauge load cells. This is because piezoelectric crystals are exceptionally stiff, yielding high natural frequencies. Conversely, strain gauge load cells feature a relatively massive structure and lower spring stiffness, giving them a lower natural frequency that limits their high-frequency performance.

178. (D) Pressure is measured between two fixed vertical depths.
Liquid density can be determined by measuring hydrostatic pressure. According to the hydrostatic equation, pressure is the product of density, gravity, and liquid height. By placing a differential pressure transmitter to measure pressure between two fixed vertical heights in a vessel, the height remains constant, and the output varies directly with fluid density.

179. (A) It is the mass of water vapor per unit volume of moist air.
Absolute humidity is defined as the actual mass of water vapor present in a given volume of moist air, usually expressed in grams per cubic meter. Unlike relative humidity, which is temperature-dependent, absolute humidity directly measures the physical density of the water vapor in the atmosphere, regardless of the air's temperature.

180. (C) A chilled-mirror dew point hygrometer
A chilled-mirror dew point hygrometer is recognized as a primary standard for humidity measurement. It operates by cooling a gold or platinum mirror surface until water vapor condenses on it. The temperature at which condensation begins is the dew point, which correlates directly to water vapor pressure and absolute humidity, requiring no calibration.

Downloaded from www.pdf.tube

181. (A) I and III
The slope of the Nernst equation is directly proportional to temperature. Glass electrodes have an extremely high electrical resistance, often in the range of ten to one hundred megaohms, requiring very high-impedance amplifiers to prevent signal distortion. Reference electrodes must maintain a constant, stable potential, unlike measuring electrodes which provide variable potentials.

182. (D) Broad and relatively flat across a wide range of wavelengths
Thermal detectors absorb incident electromagnetic radiation and measure the resulting temperature rise of their active element. Because this absorption process is thermal rather than quantum, it does not depend on a specific photon energy threshold. Consequently, devices like bolometers and thermopiles offer a broad, relatively flat spectral response across a very wide wavelength range.

183. (D) 16
According to the Stefan-Boltzmann law, the total radiant energy emitted per unit surface area of a blackbody is directly proportional to the fourth power of its absolute thermodynamic temperature. When the absolute temperature of the blackbody is doubled, the total radiant emission increases by a factor of two raised to the fourth power, which equals sixteen.

184. (B) 0.35 degrees
An absolute optical encoder's resolution depends on the number of tracks, which corresponds to binary bits. A ten-track disk yields ten bits, creating two raised to the power of ten, or one thousand twenty-four, unique position codes. Dividing a full three hundred sixty degree rotation by this value yields approximately zero point thirty-five degrees.

185. (A) I and III
Gray code is an unweighted binary system where adjacent values differ by only one single bit. This property minimizes multi-bit read transition errors, making it highly reliable for optical encoders. Conversion from Gray code to standard binary representation is straightforward and can be easily performed in digital systems using a cascade of exclusive-OR logic gates.

186. (A) P-3, Q-4, R-1, S-2
Advanced sensors utilize diverse physics phenomena. SAW sensors propagate acoustic waves across a piezoelectric crystal. Magneto-diodes rely on carrier recombination rates being altered by external magnetic fields. In phototransistors, incident photons directly generate the internal base current. Quartz thermometers utilize the temperature-dependent resonant frequency shift of a specifically cut quartz crystal to achieve highly precise readings.

187. (A) Both A and R are true and R is the correct explanation of A.
Surface Acoustic Wave sensors operate without any integrated battery, making them passive devices. This is achieved because the sensor's antenna intercepts the incoming electromagnetic interrogation pulse. This radio-frequency energy is converted by an interdigital transducer into mechanical surface acoustic waves, which then propagate, reflect, and are converted back into a returned radio-frequency signal.

NODIA

188. (C) Giant Magnetoresistance (GMR) sensor
Giant Magnetoresistance sensors utilize a quantum mechanical effect observed in thin-film structures with alternating ferromagnetic and non-magnetic conductive layers. When an external magnetic field is applied, the relative magnetization directions of the ferromagnetic layers align. This alignment significantly reduces the structure's electrical resistance, allowing highly sensitive and localized magnetic field detection.

189. (A) Blooming
Blooming in Charge-Coupled Devices occurs under high-intensity light. When a pixel's potential well is saturated with photo-generated electrons, the excess charge cannot be contained. Consequently, the surplus electrons spill over into adjacent pixels along the same register column, creating white streaks or halo artifacts in the captured digital image file.

190. (C) Thermal generation of electron-hole pairs
Dark current is the unwanted electrical current that flows through an optical sensor even when it is in complete darkness. The primary source of this noise is the thermal generation of electron-hole pairs within the silicon substrate. Heat energy excites valence electrons into the

conduction band, mimicking the effect of incident light.

191. (A) Transducer → Signal Conditioning → Anti-aliasing Filter → ADC → Microprocessor
A digital data acquisition system processes signals in a logical order. First, a transducer converts the physical quantity into an electrical signal. Next, signal conditioning amplifies or filters this raw voltage. An anti-aliasing filter then removes high-frequency components before the analog-to-digital converter digitizes the signal for processing by a microprocessor.

192. (C) Its output instantaneously follows the input.
A zero-order measurement system represents an idealized system where the output is directly and instantaneously proportional to the input. This means there are no energy storage elements like mass, capacitance, or thermal capacity to introduce dynamic lag or phase shifts, allowing the sensor output to track the input without delay.

193. (B) The scale readability of the pointer
In an analog moving-coil voltmeter, the resolution is restricted by the observer's ability to read the pointer position on the graduated scale. Unlike digital voltmeters that provide discrete numerical displays, the analog scale's divisions, pointer thickness, and human visual acuity define the smallest readable change in voltage.

194. (D) 0.20 °C
Standard deviation is a fundamental statistical metric used to quantify the spread of measurement data. It is mathematically defined as the positive square root of the variance. For a temperature sensor displaying a variance of zero point zero four square degrees Celsius, taking the square root yields a standard deviation of zero point twenty degrees Celsius.

195. (A) P-2, Q-4, R-3, S-1
Different types of measurement errors require specific mitigation strategies. Parallax error is avoided by placing a mirror behind the pointer to align the line of sight. Random electronic noise is mitigated using signal averaging or low-pass filtering. Temperature drift requires active temperature compensation circuits, while zero offset error is corrected through calibration adjustment.

196. (A) II and III
First-order dynamic systems cannot overshoot when responding to step inputs, regardless of input magnitude. In contrast, second-order systems will oscillate if their damping ratio is less than unity. For a first-order system tracking a unit ramp input, the steady-state dynamic error is mathematically equal to the system's characteristic thermal or electrical time constant.

197. (A) Decreasing the physical junction mass
The thermal time constant of a bare thermocouple is directly proportional to its mass and specific heat capacity, and inversely proportional to its surface area and heat transfer coefficient. Decreasing the physical mass of the sensing junction reduces the heat energy required to alter its temperature, allowing the sensor to respond much faster.

198. (A) Both A and R are true and R is the correct explanation of A.
Potentiometers are classic variable voltage dividers used to measure physical displacement. They consist of a resistive element and a sliding wiper contact. The wiper's mechanical position divides the total track resistance into two parts, producing an output voltage that is a direct fraction of the applied excitation voltage, proportional to displacement.

199. (B) Thermal expansion coefficient
In high-temperature applications, mismatched thermal expansion between a strain gauge and the test specimen causes false strain measurements, known as apparent strain. To minimize this effect, the thermal expansion coefficient of the strain gauge foil must be matched to that of the test specimen, ensuring thermal expansion does not generate false resistance changes.

200. (C) It causes signal attenuation and temperature errors.
Long lead wires introduce parasitic electrical resistance in series with a quarter-bridge strain gauge. This additional resistance attenuates the measurement signal by reducing the overall bridge sensitivity. Furthermore, because lead wire resistance fluctuates with ambient temperature, it introduces temperature-induced measurement drift errors, compromising the accuracy of the final strain reading.

Click Here to Buy book on Amazon

201. (D) Series opposing connection of secondaries
An LVDT uses a series opposing configuration for its two secondary coils. At the center null position, the magnetic flux coupling from the primary coil to each secondary coil is equal. This induces identical voltages in both secondaries, which, being connected in series opposition, cancel each other out completely, yielding a net output of zero.

202. (A) The square of the gap distance
The capacitance of a parallel-plate capacitor is inversely proportional to the air-gap distance. To find sensitivity, we differentiate capacitance with respect to the gap distance. This differentiation shows that the sensitivity is inversely proportional to the square of the gap distance, meaning sensitivity increases dramatically as the plates move closer together.

203. (A) I and II
Ultrasonic transducers operate in the megahertz frequency range for industrial and medical applications. A coupling medium, like gel, is essential because acoustic waves reflect almost completely at air-solid boundaries due to acoustic impedance mismatches. However, these transducers can easily measure distances in gases, as seen in standard non-contact industrial level sensors.

204. (A) P-2, Q-3, R-1
Different temperature sensors are limited by their material properties. Platinum Resistance Temperature Detectors typically operate up to eight hundred fifty degrees Celsius before degradation occurs. Semiconductor thermistors have high sensitivity but are restricted to around three hundred degrees Celsius. Optical pyrometers are non-contact instruments designed for high temperatures, typically exceeding fifteen hundred degrees Celsius.

205. (A) Type S (Platinum/Rhodium)
Type S thermocouples are made from noble metals, specifically platinum and a platinum-rhodium alloy. This composition provides exceptional chemical inertness and resistance to oxidation at high temperatures. Consequently, Type S thermocouples offer extremely high stability, reproducibility, and accuracy, making them the standard choice for laboratory calibration of other industrial temperature sensors.

206. (C) Rotameter
Diaphragm pressure sensors function by translating fluid pressure into a mechanical deflection of a thin metallic or ceramic membrane. This microscopic displacement is subsequently converted into an electrical signal using strain gauges, capacitive gap sensors, or LVDTs. A rotameter is a variable-area flow meter and is never used to measure diaphragm deflection.

207. (A) Both A and R are true and R is the correct explanation of A.
Orifice meters require a longer straight pipe run upstream compared to Venturi tubes. This is because the abrupt physical restriction of the thin orifice plate generates severe turbulent flow disturbances. To apply standard discharge coefficients accurately, the incoming flow must be fully developed and symmetric, necessitating a longer straight conditioning section of pipe.

208. (C) Upward forces balance downward gravity.
In a variable-area rotameter, the physical float reaches equilibrium and stabilizes at a specific height within the tapered tube. This occurs when the net upward forces, which consist of the fluid's buoyant force and the dynamic drag force exerted by the upward flow, exactly balance the downward force of gravity acting on the float.

209. (B) The distance between the electrodes
Faraday's Law of Electromagnetic Induction states that the voltage induced in a moving conductor is proportional to the magnetic field, conductor velocity, and conductor length. In an electromagnetic flow meter, the moving conductor is the flowing conductive liquid. The length of this conductor corresponds to the distance between the two measuring electrodes.

NODIA

210. (D) Vortex shedding flow meter
The Strouhal number is a fundamental dimensionless parameter used to characterize oscillating flow mechanisms. In a vortex shedding flow meter, it relates the frequency of vortex shedding behind a bluff body to the fluid velocity and the width of the bluff body. This relationship remains constant over a wide range of Reynolds numbers.

211. (A) Piezoelectric accelerometer
Piezoelectric accelerometers are exceptionally rugged sensors featuring very high mechanical stiffness. This stiffness results in an extremely high

resonant frequency, making them ideal for high-frequency shock and vibration measurements. Because piezoelectric crystals only generate electrical charge in response to dynamic forces, they cannot measure steady-state DC or static gravitational acceleration fields.

212. (A) I and II
Proving rings are highly reliable elastic devices used for calibrating force-measuring instruments. The physical deflection of the ring under an applied load is typically measured using a highly accurate micrometer or a vibrating reed. Proving rings are made of stable steel alloys and have low temperature sensitivity, so temperature effects are minor.

213. (A) P-4, Q-3, R-2, S-1
Different sensors are optimized for specific parameters. Relative humidity is measured with capacitive polymer hygrometers. Shaft torque is measured using bonded strain gauges mounted at forty-five degrees to detect shear strain. The pH value of solutions is monitored using a glass electrode, and mechanical vibrations are measured using a seismic displacement pickup.

214. (D) 0.00 V at all temperatures
The Standard Hydrogen Electrode serves as the universal reference standard in electrochemistry. By international convention, the thermodynamic potential of this electrode is defined to be exactly zero volts at all temperatures. This arbitrary baseline provides a stable, zero-volt reference point against which the potentials of all other electrochemical half-cells are measured and compared.

215. (B) Absorbs all radiation and is a perfect emitter
A blackbody is an idealized physical body used as a standard in thermodynamics and radiation physics. It is defined as a perfect absorber that absorbs all incident electromagnetic radiation, regardless of wavelength or angle. According to Kirchhoff's law, a perfect absorber is also a perfect emitter, releasing the maximum possible thermal radiation at any given temperature.

216. (C) Two gratings superimposed at a slight angle
Moiré fringe techniques are used in high-precision displacement sensing. The assembly consists of two identical optical gratings with fine line patterns superimposed at a very small angle. When relative physical movement occurs, a magnified pattern of dark and light fringes, known as Moiré fringes, is generated, enabling highly sensitive position and alignment measurement.

217. (C) A is true but R is false.
Gray code is widely used in absolute optical encoders because it represents a cyclic code. However, the defining advantage of Gray code is that only one single bit changes state between any two consecutive values. This single-bit transition property prevents multi-bit read discrepancies at boundary zones, rather than speeding up processing.

218. (A) Coated with a mass-sensitive selective polymer
Surface Acoustic Wave sensors can detect chemical concentrations by applying a mass-sensitive selective polymer coating to the delay line. When exposed to target gas molecules, the polymer layer selectively absorbs them, increasing the physical mass of the coating. This mass change slows down the acoustic wave propagation, altering the resonant frequency.

219. (B) They are exclusively used for detecting high-frequency AC magnetic fields.
Hall effect sensors are highly versatile magnetic field detectors. They operate by measuring the transverse voltage generated when a current-carrying conductor is exposed to a magnetic field. Because they respond to the absolute magnetic flux density, they detect both static DC and changing AC magnetic fields, rather than being restricted to high frequencies.

220. (B) Inherent signal amplification
While photodiodes are faster and offer better linearity, phototransistors provide the key advantage of inherent signal amplification. The photo-generated charge carriers created in the base-collector junction act as base current, which is internally multiplied by the transistor's current gain. This produces a significantly larger output current for a given light intensity.

221. (A) I and II
CCD sensors transfer photo-generated charge packets sequentially across pixels to a single common readout amplifier. In contrast, CMOS sensors incorporate an individual pixel amplifier for each photo-site, allowing parallel readout. CMOS architectures typically suffer more from

Downloaded from www.pdf.tube

rolling shutter artifacts, whereas CCDs generally use global shutters that capture all pixel images simultaneously.

222. (C) Data transmission element
A generalized measurement system contains functional blocks that handle signals sequentially. A telemetry link is used to send measurement data from a remote sensor to a centralized monitoring or recording station. Consequently, it is classified as a data transmission element, responsible for conveying the signal without altering its information content.

223. (D) Analog output is continuous, digital is discrete.
The primary distinction between analog and digital transducers lies in the format of their output signals. Analog transducers produce a continuous output signal that varies smoothly and proportionally with the measured parameter. Conversely, digital transducers output discrete, coded signals or pulses that represent the measured physical value in a quantized digital format.

224. (C) Difference between upper and lower range values
The span of a measuring instrument is a fundamental range parameter. It is mathematically calculated as the algebraic difference between the upper range value and the lower range value. For instance, if a temperature sensor is calibrated to measure from fifty to two hundred degrees, its operational span is exactly one hundred fifty degrees.

225. (A) Both A and R are true and R is the correct explanation of A.
Hysteresis represents a critical source of error in transducers, causing different outputs for the same input depending on whether the input is increasing or decreasing. This occurs because physical materials exhibit magnetic or elastic memory. Internal friction and alignment delay prevent the material from returning instantly to its original physical state upon unloading.

226. (D) It has the same units as the variable.
While both variance and standard deviation quantify the spread of measurement data, standard deviation is preferred for reporting error bounds. Variance is calculated by squaring deviations, which results in squared units. Taking the square root to find the standard deviation restores the units to match those of the measured physical variable.

227. (A) P-4, Q-2, R-1, S-3
Dynamic specifications characterize system speed and stability. Rise time is the time needed to go from ten to ninety percent of the final value. Settling time is the duration required to stay within an error band. Peak overshoot is the maximum deviation past the final value, and phase shift represents the output angular delay.

228. (C) Time constant
In a first-order dynamic system, responding to a ramp input results in a steady-state dynamic lag. The magnitude of this tracking error is directly equal to the system's characteristic time constant. A larger time constant indicates a slower system response, which increases the physical lag between the changing input ramp and the measured output signal.

NODIA

229. (A) It will overshoot slightly and settle rapidly.
A second-order system with a damping ratio of zero point seven hundred seven represents an underdamped system. This specific damping value is often considered optimal because it provides a rapid response speed. When subjected to a step input, the system's output will overshoot the final value slightly, around four percent, and settle very quickly.

230. (B) 0.2%
The theoretical resolution of a wire-wound potentiometer is defined by the physical spacing between individual wire turns. It is calculated by dividing one by the total number of turns, and then multiplying by one hundred to express the result as a percentage. For a five hundred turn potentiometer, this calculation yields exactly zero point two percent.

231. (C) I, II and III
In metallic strain gauges, the gauge factor is primarily derived from physical dimensional changes under strain. Conversely, semiconductor gauges utilize the piezoresistive effect, which alters bulk material resistivity under stress. Semiconductor gauges offer extremely high sensitivity but exhibit poor temperature stability, requiring active temperature compensation circuits to ensure measurement accuracy.

232. (C) The mutual inductance between coils
An LVDT operates on the principle of variable mutual inductance. When an AC excitation voltage is applied to the primary coil, it creates a magnetic field. Physical displacement of the ferromagnetic core inside the coils modulates the mutual inductance between the primary coil and the two secondary coils, altering the induced secondary voltages.

233. (D) Detecting the level of a non-conducting liquid
Variable dielectric capacitive sensors are ideal for detecting the level of non-conducting liquids. The sensor consists of two parallel plates immersed in a vessel. As the liquid level rises, it displaces air between the plates. Because the liquid has a higher dielectric constant than air, this physical displacement directly increases the measured capacitance.

234. (B) 2.3 pC/N
The piezoelectric charge coefficient represents the electrical charge generated per unit of applied mechanical force. For natural quartz crystals cut along the electrical axis, this constant is relatively small compared to synthetic ceramics. It is approximately two point three picocoulombs per newton, providing a highly stable and precise, though low-magnitude, charge output.

235. (A) Both A and R are true and R is the correct explanation of A.
Charge amplifiers are widely used with piezoelectric sensors because they eliminate cable capacitance effects. The amplifier design employs high negative feedback, which maintains a virtual ground at the input terminals. Because the input voltage remains effectively at zero, no electrical charge can accumulate on the cable, preventing cable length from altering measurement sensitivity.

236. (B) Bending due to differential expansion
A bimetallic thermometer consists of two strips of different metals bonded together along their length. These metals possess distinct coefficients of thermal expansion. When heated or cooled, one metal expands or contracts more than the other, forcing the bonded strip to bend. This physical deflection is mechanically linked to a pointer to display temperature.

237. (A) P-3, Q-1, R-2, S-4
Industrial temperature measurement requires selecting sensors matched to the application. High-temperature furnaces around fourteen hundred degrees Celsius require Type S thermocouples or non-contact optical pyrometers. Highly precise laboratory tasks at one hundred degrees are best served by platinum RTDs, while robust, low-cost plant monitoring utilizes Type J, and tiny points require bare fine-wire thermocouples.

238. (C) Voltage depends on the difference between two junctions.
Thermocouples do not measure absolute temperature directly. Instead, they generate an electromotive force that depends on the temperature difference between the hot measuring junction and the cold reference junction. To determine the absolute temperature of the hot junction, the real-time temperature of the reference junction must be measured and compensated for in calculations.

239. (D) Hydraulic oil
Dead-weight testers require a working fluid to transmit pressure from the piston to the gauge under calibration. For high-pressure calibration, hydraulic oil is commonly used because it is nearly incompressible and provides essential lubrication for the rotating piston. This reduces friction and prevents wear, ensuring highly accurate and reproducible pressure measurements.

240. (C) Stiffness of the diaphragm material
When pressure is applied to a diaphragm transducer, the membrane deforms physically. The restoring force that resists this deflection and returns the membrane to its original flat shape upon pressure release is provided by the inherent elastic stiffness of the diaphragm material itself, typically made from high-strength metals or ceramics.

241. (A) I and II
Pitot-static tubes measure local fluid velocity by detecting the difference between impact and static pressure, known as dynamic pressure. Accurate measurements require precise alignment with the flow direction to avoid velocity vector errors. However, they only measure velocity at a single point and cannot directly provide average bulk flow in turbulent environments.

Click Here to Buy book on Flipkart

242. (A) Both A and R are true and R is the correct explanation of A.
Electromagnetic flow meters are highly advantageous in industrial piping because they introduce zero permanent pressure drop. Since the meter construction features a completely unobstructed, straight-through flow design with flush electrodes, the fluid experiences no physical resistance, restriction, or friction loss, maintaining line pressure completely across the sensor.

243. (A) A downstream pressure sensor
Vortex shedding flow meters place a non-streamlined bluff body in the flow stream, causing vortices to shed alternately on either side. This shedding generates localized, periodic pressure fluctuations in the fluid. A highly sensitive downstream pressure sensor, such as a piezoelectric crystal, detects these frequency oscillations to calculate the fluid velocity.

244. (C) Much lower than the vibration frequency being measured
To measure physical displacement accurately, a seismic pickup must have a natural frequency much lower than the excitation vibration frequency. Under this condition, the internal seismic mass remains virtually stationary in space due to its inertia, allowing the housing's relative movement around the mass to represent the true external displacement of the vibrating structure.

245. (A) P-2, Q-4, R-1, S-3
MEMS accelerometers consist of several micro-machined functional components. The proof mass generates inertial forces under acceleration. Interleaved comb fingers act as variable capacitors to detect physical displacement. Suspension springs provide mechanical stiffness, determining the natural frequency, while a gas damping medium prevents excessive resonant peaking by dissipating excess kinetic energy.

246. (D) Four 45-degree gauges in a full bridge
Torsional load on a cylindrical shaft generates maximum tensile and compressive shear strains at forty-five degrees relative to the shaft axis. Mounting four gauges at this angle in a full Wheatstone bridge provides maximum sensitivity for torque measurement. This symmetric configuration also cancels out unwanted bending and axial strain interference components.

247. (B) The applied force linearly
Proving rings operate on the principles of structural elasticity. When a tensile or compressive force is applied across the ring, the steel body undergoes elastic deformation. Within the material's elastic limit, this physical deflection is directly proportional to the applied force, establishing a highly linear relationship useful for precise force calibration.

248. (C) Absorbs moisture, changing its dielectric constant
Capacitive polymer hygrometers employ a thin, active polymer film as the dielectric layer between two electrodes. This specialized polymer absorbs water molecules from the surrounding air in proportion to the relative humidity. Since water has a high dielectric constant, its absorption increases the overall dielectric constant of the film, changing the measured capacitance.

249. (D) An ultrasonic densitometer
Measuring the density of a flowing liquid without physical contact is best achieved using an ultrasonic densitometer. By transmitting acoustic waves through the pipe walls, the system measures the acoustic impedance and wave propagation velocity. This completely non-invasive method calculates fluid density in real time, avoiding any corrosion or process contamination issues.

NODIA

250. (A) Activity of the target ion
Activity of the target ion is correct because the Nernst equation relates the electrode potential to the logarithm of the ion's activity, which reflects its effective concentration in solution. Ion-selective electrodes respond to ionic activity rather than total concentration, especially in non-ideal solutions. Temperature influences the Nernst slope but is not the logarithmic term, while solution volume and conductivity do not directly determine electrode potential.

251. (A) I and II
Statements I and II are correct because optical pyrometers determine temperature by matching the brightness of a hot object using the human eye or a photodetector, based on thermal radiation described by Planck's law. Statement III is incorrect because optical pyrometers are designed for measuring high temperatures, generally well above 500 °C, where sufficient thermal radiation is emitted.

252. (B) Gray Code
Gray Code is correct because only one bit changes between successive code positions, minimizing reading errors caused by slight misalignment during encoder transitions. This property prevents large position errors in absolute digital encoders. Binary Coded Decimal, ASCII, and hexadecimal representations do not possess this single-bit transition characteristic and are therefore less suitable for absolute position encoding.

253. (A) Piezoelectricity
Piezoelectricity is correct because Surface Acoustic Wave (SAW) sensors generate and detect acoustic waves using piezoelectric materials such as quartz or lithium niobate. Mechanical or environmental changes alter wave velocity or frequency, enabling accurate sensing. Ferromagnetism, thermoelectricity, and photoemission are unrelated to the operating principle of SAW sensors.

254. (A) Both A and R are true and R is the correct explanation of A.
Both the assertion and reason are true, and the reason correctly explains the assertion. Applying reverse bias to a photodiode widens the depletion region and strengthens the electric field across the junction. This rapidly sweeps photogenerated charge carriers across the junction, reducing carrier transit time and improving response speed in photoconductive mode.

255. (D) Semiconductors
Semiconductors are correct because they have relatively low carrier concentration and high carrier mobility, producing a much larger Hall voltage than most metals under the same magnetic field. This makes them highly suitable for Hall-effect sensors. Pure noble metals exhibit a much weaker Hall effect, while superconductors and ferromagnetic insulators are not commonly used for conventional Hall sensors.

256. (C) Clocked gate voltages to form potential wells
Clocked gate voltages are correct because a Charge-Coupled Device (CCD) transfers stored charge packets from one pixel to the next by sequentially varying gate voltages, creating moving potential wells within the semiconductor. This enables efficient image readout with low noise. Permanent magnets, piezoresistive membranes, and mechanical vibration are not involved in CCD charge transfer.

257. (B) Repeatability
Repeatability is correct because it describes an instrument's ability to produce the same output when identical input conditions are repeatedly applied under unchanged operating conditions. High repeatability indicates consistent performance and good precision. Linearity measures proportionality, sensitivity measures output change per unit input, and resolution indicates the smallest detectable change.

NODIA

258. (D) Predictable and consistent
Predictable and consistent is correct because a systematic error introduces a constant or reproducible bias that shifts measurements in the same direction each time. Such errors usually arise from calibration faults, instrument defects, or incorrect measurement techniques. Random errors vary unpredictably, while transcription mistakes are considered human errors rather than systematic measurement errors.

259. (A) Underdamped
Underdamped is correct because a damping ratio (ζ) between 0 and 1 indicates that the system oscillates with gradually decreasing amplitude before reaching equilibrium. A value of $\zeta = 0.5$ therefore represents an underdamped system. Critical damping occurs at $\zeta = 1$, overdamping occurs when $\zeta > 1$, and an undamped system has $\zeta = 0$.

260. (A) P-2, Q-1, R-4, S-3
This matching is correct because strain gauges measure resistance changes caused by strain, thermocouples generate voltage through the Seebeck effect under a temperature gradient, capacitive micrometers detect displacement by capacitance changes, and piezoelectric crystals produce electric charge when subjected to force. Each sensor operates on a distinct physical principle suitable for its respective measurement.

261. (B) Two
Two is correct because a Linear Variable Differential Transformer (LVDT) consists of one primary winding placed between two identical secondary windings connected in series opposition. Movement of the magnetic core changes the induced voltages in the secondary coils, producing an output proportional to

displacement. This differential arrangement provides high sensitivity and excellent linearity.

262. (A) I and II
Statements I and II are correct because Resistance Temperature Detectors (RTDs) have a positive temperature coefficient, meaning their electrical resistance increases with temperature. Self-heating caused by measurement current can introduce significant errors if excessive current is used. Statement III is incorrect because the Seebeck effect is the operating principle of thermocouples, not RTDs.

263. (B) The actual applied pressure
The actual applied pressure is correct because a dead-weight tester generates pressure using the relationship $\text{Pressure} = \frac{\text{Force}}{\text{Area}}$.
Since the applied force is accurately known from calibrated weights, the piston area must also be precisely known to determine the true pressure. Fluid viscosity, humidity, and ambient temperature are not the primary quantities calculated from piston area.

264. (C) High non-recoverable pressure loss
High non-recoverable pressure loss is correct because an orifice plate creates substantial turbulence and energy dissipation, resulting in a permanent pressure drop greater than that of a Venturi tube. Although inexpensive and simple, this energy loss is its principal disadvantage. Orifice meters can measure gas flow and usually occupy less installation space than Venturi tubes.

265. (D) Simultaneous rotation of a tube and internal fluid flow
Simultaneous rotation of a vibrating tube and internal fluid flow is correct because the moving fluid experiences Coriolis forces that twist the oscillating tube. The magnitude of this deflection is directly proportional to the mass flow rate, allowing highly accurate measurement. Magnetic interactions, vortex shedding, and thermal expansion are unrelated to the Coriolis measurement principle.

266. (A) Both A and R are true and R is the correct explanation of A.
Both the assertion and reason are true, and the reason correctly explains the assertion. Capacitive accelerometers can measure constant acceleration, including gravity, because a proof mass undergoes steady deflection under DC acceleration. This changes the spacing between capacitor plates, producing a measurable change in capacitance proportional to the applied acceleration.

267. (B) Changing coil inductance in an AC circuit
Changing coil inductance in an AC circuit is correct because variable reluctance force sensors operate by altering the magnetic reluctance of the magnetic path, thereby changing coil inductance. An electronic oscillator converts these inductance changes into measurable electrical signals. They do not generate direct DC voltage, modulate laser intensity, or rely on piezoelectric effects.

268. (B) Provide a stable, known potential
Provide a stable, known potential is correct because the reference electrode maintains a constant electrical potential independent of the sample composition. The ion-selective electrode measures the potential difference between itself and this stable reference to determine ion activity. The reference electrode neither attracts ions nor measures solution temperature or provides mechanical agitation.

269. (D) I, II and III
All three statements are correct. Incremental encoders lose position information after power failure because they measure relative movement. Absolute encoders assign a unique binary or Gray code to every shaft position, preserving position information after power restoration. Optical encoders also use Moiré fringe principles in certain designs to improve measurement resolution and accuracy.

270. (C) Recombination rate of deflected carriers
Recombination rate of deflected carriers is correct because an applied magnetic field deflects charge carriers within a magneto-diode, altering their recombination rate and thereby changing the device current. This effect provides high magnetic field sensitivity. The total diode length, semiconductor thermal conductivity, and intrinsic bandgap energy are not the primary mechanisms governing magneto-diode operation.

****

Downloaded from www.pdf.tube

CHAPTER 02
Signal Conditioning Circuits

2012

1. In signal conditioning, impedance matching for maximum voltage transfer requires which of the following conditions between the sensor output impedance ($Z_{\{out\}}$) and amplifier input impedance ($Z_{\{\in\}}$)?
(A) $Z_{\{out\}}$ must be strictly equal to $Z_{\{\in\}}$.
(B) $Z_{\{\in\}}$ must be significantly greater than $Z_{\{out\}}$.
(C) $Z_{\{out\}}$ must be significantly greater than $Z_{\{\in\}}$.
(D) $Z_{\{\in\}}$ must be complex conjugate to $Z_{\{out\}}$.

2010

2. Which of the following defines the "loading effect" in an analog measurement system?
(A) The physical weight of the sensor modifying the target object.
(B) The increase in signal-to-noise ratio due to excessive input impedance.
(C) The accumulation of parasitic capacitance in long cables.
(D) The reduction of measured voltage due to current drawn by the measuring instrument.

2002

3. Identify the correct statement regarding Signal-to-Noise Ratio (SNR) in a sensing system.
(A) SNR is defined as the ratio of the power of a signal to the power of background noise.
(B) A higher SNR indicates that noise dominates the measurement.
(C) SNR is typically improved by decreasing the common-mode rejection ratio.
(D) Decreasing the bandwidth of the system universally degrades the SNR.

2021

4. Which of the following is an INCORRECT statement regarding impedance matching in power transfer versus voltage measurement?
(A) Maximum power transfer occurs when load impedance equals source impedance.
(B) Mismatched impedances in high-frequency circuits cause signal reflections.
(C) Voltage measurements require a low input impedance amplifier to minimize noise.
(D) High input impedance amplifiers minimize current draw from the sensor.

2019

5. A piezoelectric sensor with a high output impedance of $10M\Omega$ is best interfaced with which of the following to prevent signal attenuation?
(A) A voltage follower with an input impedance of $100G\Omega$.
(B) An inverting amplifier with an input resistor of $10k\Omega$.
(C) A standard bipolar junction transistor (BJT) emitter follower.
(D) A direct analog-to-digital converter with a $1M\Omega$ input impedance.

2006

6. What is the primary cause of thermal (Johnson-Nyquist) noise in signal conditioning circuits?
(A) Electromagnetic interference coupled from nearby power lines.
(B) Voltage fluctuations originating in unstable DC power supplies.
(C) Rectifying effects inside active semiconductor PN junctions.
(D) Random thermal motion of charge carriers in a conductor.

NODIA

2018

7. Which classification of noise is inversely proportional to frequency and dominates at low frequencies in electronic components?
(A) Shot (quantum) noise
(B) Flicker ($\frac{1}{f}$) noise
(C) Avalanche breakdown noise
(D) Burst (popcorn) noise

2019

8. In an ideal operational amplifier, what are the theoretical values for input impedance and output impedance, respectively?
(A) Zero and Infinite
(B) Infinite and Infinite
(C) Infinite and Zero
(D) Zero and Zero

2024

9. Identify the INCORRECT statement regarding the inverting configuration of an operational amplifier.

(A) The non-inverting input is typically connected to ground.
(B) It relies on the concept of a virtual ground at the inverting input.
(C) The input impedance is determined by the input resistor.
(D) The closed-loop gain is determined solely by the feedback resistor.

2024

10. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): A non-inverting operational amplifier configuration is often preferred over an inverting configuration for buffering high-impedance sensors.

Reason (R): The non-inverting configuration provides an extremely high input impedance, minimizing the loading effect on the sensor.

In light of the above statements, choose the correct answer from the options given below:

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

11. What is the primary effect of input offset voltage in an operational amplifier used for DC signal amplification?

(A) It causes high-frequency oscillations that degrade overall stability.
(B) It creates a constant DC output error when the input is zero.
(C) It significantly reduces the maximum slew rate of the output signal.
(D) It restricts the allowable range of the common-mode input voltage.

2003

12. Which circuit technique is primarily used to compensate for input bias current errors in an operational amplifier circuit?

(A) Placing a noise-filtering capacitor in parallel with the feedback resistor.
(B) Adding a compensation resistor at the non-inverting input.
(C) Employing a high-performance chopper-stabilized amplifier architecture.
(D) Increasing the operational amplifier power supply voltage.

2018

13. A quarter-bridge Wheatstone configuration is most accurately defined as having how many variable resistive elements?

(A) One
(B) Two
(C) Three
(D) Four

2022

14. What is the primary advantage of a full-bridge (four-variable element) Wheatstone bridge over a quarter-bridge?

(A) It simplifies the interface by requiring fewer external wiring connections.
(B) It operates passively and eliminates the need for an excitation voltage.
(C) It offers maximum sensitivity and temperature compensation.
(D) It completely isolates the sensor to prevent ground loop interference.

2015

15. In a balanced Wheatstone bridge, what is the theoretical voltage difference between the two measurement nodes?

(A) Equal to the excitation voltage
(B) Half of the excitation voltage
(C) Dependent solely on the lead wire resistance
(D) Zero volts

2023

16. Identify the correct equation for the output voltage ($V_{\{out\}}$) of an initially balanced quarter-bridge with excitation $V_{\{ex\}}$, assuming a small change in resistance (ΔR) in one arm (where all arms are nominally R).

(A) $V_{out} = V_{ex} \times \frac{\Delta R}{R}$

(B) $V_{out} = V_{ex} \times \frac{\Delta R}{2R}$

(C) $V_{out} = V_{ex} \times \frac{\Delta R}{4R}$

(D) $V_{out} = V_{ex} \times \frac{\Delta R}{8R}$

2019

17. Which of the following best explains why constant current excitation is sometimes preferred over constant voltage excitation for resistive sensors located far from the measurement system?

(A) It simplifies signal conditioning by

Click Here to Buy book on Amazon

eliminating the instrumentation amplifier.
(B) It eliminates the measurement error caused by lead-wire voltage drops.
(C) It controls the sensor excitation current to prevent self-heating entirely.
(D) It linearizes the non-linear relationship of resistive temperature sensors.

2011

18. What is a key disadvantage of continuous constant voltage excitation in a Wheatstone bridge utilizing strain gauges?
(A) It produces a highly non-linear output response during large resistance variations.
(B) It exposes the bridge to low-frequency noise and $\frac{1}{f}$ flicker noise.
(C) It necessitates complex demodulation circuitry to extract the output signal.
(D) It causes self-heating, which drifts gauge resistance.

2017

19. Pulsed-mode bridge excitation techniques are primarily implemented to achieve which of the following?
(A) To minimize sensor self-heating and conserve power.
(B) To increase the frequency response of the strain gauge.
(C) To convert the analog voltage directly into a digital signal.
(D) To eliminate the need for analog-to-digital converters.

2010

20. Match the operational amplifier characteristics in List I with their corresponding descriptions in List II.
List I: (Characteristic)
P. Slew Rate
Q. CMRR
R. Input Offset Voltage
S. Gain-Bandwidth Product
List II: (Description)
1. Ability to reject signals common to both inputs
2. Maximum rate of change of the output voltage
3. Constant indicating high-frequency performance limits
4. Voltage required at input to force output to zero
Choose the correct answer from the options given below:
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

NODIA

2010

21. Which architecture is standard for a classic Instrumentation Amplifier (INA)?
(A) Three operational amplifiers: two buffers and a differential stage.
(B) A single operational amplifier topology utilizing precise differential input resistors.
(C) Two operational amplifiers configured to function as precise current-to-voltage converters.
(D) Four operational amplifiers arranged to provide completely isolated signal grounds.

2019

22. What is the fundamental purpose of the Common-Mode Rejection Ratio (CMRR) in an Instrumentation Amplifier?
(A) To selectively amplify the DC offset voltage of the input signal.
(B) To maximize the operating bandwidth of the entire measurement system.
(C) To convert a differential voltage into a common-mode output current.
(D) To suppress identical noise signals on both inputs.

2025

23. Identify the INCORRECT statement concerning Instrumentation Amplifiers (INAs).
(A) Their gain can typically be set by adjusting a single external resistor.
(B) They are exclusively used for converting current to voltage.
(C) They possess very high input impedance on both input terminals.
(D) The input stage is designed to draw minimal current from the sensor.

2009

24. Which of the following is the most effective method for common-mode voltage minimization at the source in a bridge measurement system?
(A) Using an asymmetrical, unbalanced bridge circuit configuration.
(B) Grounding one side of the reference excitation source and the system output.
(C) Using a balanced, symmetrical bridge with shielded twisted-pair cables.
(D) Reducing the reference excitation voltage to a level near zero volts.

2024

25. Galvanic isolation in Isolation Amplifiers is primarily achieved using which of the following techniques?

(A) Capacitive coupling, active operational feedback, and grounded shields.
(B) Direct metallic wire connections incorporating high-value series resistors.
(C) Active low-pass analog filtering combined with digital signal processing.
(D) Optical, transformer, or capacitive coupling.

2015

26. When would a high-performance floating data amplifier be most necessary in a data acquisition system?

(A) When measuring a low-voltage sensor with high common-mode voltage.
(B) When measuring standard single-ended voltage signals from a local potentiometer.
(C) When amplifying high-frequency audio signals within a professional studio environment.
(D) When converting digital frequency-modulated pulses back into stable analog voltages.

2006

27. What is the primary function of a programmable-gain isolator in an industrial signal conditioning system?

(A) To physically amplify the microscopic mechanical displacements of a physical sensor.
(B) To isolate signals while enabling software-controlled variable gain.
(C) To provide a fixed, unalterable signal gain specifically for safety-critical systems.
(D) To generate the stable reference excitation voltage required by passive Wheatstone bridges.

2024

28. Which of the following best describes the principle of operation of a Chopper Amplifier?

(A) It slices high-frequency noise using highly sophisticated, steep low-pass analog filter networks.
(B) It modulates DC to AC, amplifies it, and synchronously demodulates it to DC.
(C) It uses high-speed mechanical relays to periodically short the analog input directly to the system ground.
(D) It rapidly chops the internal power supply rail to minimize overall thermal dissipation in the amplifier.

2019

29. Auto-zeroing techniques in amplifier design are primarily utilized to mitigate which of the following errors?

(A) DC offset drift and low-frequency $\frac{1}{f}$ noise.
(B) High-frequency electromagnetic and radio-frequency interference.
(C) Aliasing errors during high-speed analog-to-digital conversion.
(D) Quantization noise introduced in the final digital output stage.

2002

30. Consider the following statements regarding Chopper Amplifiers:

I. They are highly effective at minimizing DC drift.
II. They operate by amplifying the DC signal directly through a high-gain DC stage.
III. They utilize modulation and synchronous demodulation.

Which of the above statements is/are INCORRECT?

(A) I and II
(B) I and III
(C) II
(D) III

2017

31. What is a "ground loop" in the context of measurement interference?

(A) A specifically designed circular low-impedance ground conductor used to shield sensitive cables.
(B) The parasitic inductive loop created by coiling the primary signal wire around the ground wire.
(C) A sophisticated software processing algorithm that continuously calibrates the zero baseline.
(D) Unwanted current flowing due to potential differences between ground points.

2012

32. Which grounding mechanism is generally recommended for low-frequency ($< 1MHz$) precision measurement systems to avoid ground loops?

(A) Multi-point grounding
(B) Floating the sensor completely without any reference
(C) Single-point (star) grounding

Downloaded from www.pdf.tube

(D) Chassis grounding at every instrument node

2016

33. Multi-point grounding is typically preferred over single-point grounding in which of the following scenarios?
(A) In highly sensitive, low-frequency thermocouple measurements.
(B) In high-frequency systems where cable impedance is significant.
(C) In industrial systems measuring millivolt signals over long distances.
(D) In complex architectures requiring complete galvanic isolation between subsystems.

2009

34. Which of the following is a direct consequence of inadequate system/subsystem isolation in an industrial environment?
(A) A significantly enhanced and stabilized signal-to-noise ratio.
(B) Complete elimination of the input offset voltage of internal amplifiers.
(C) Automated impedance matching between completely different sensor types.
(D) Propagation of damaging high-voltage transients.

2023

35. Shielded signal cable primarily protects the internal conductors from which type of interference?
(A) Capacitively coupled electrostatic noise.
(B) Microscopic localized thermal gradients within the cable.
(C) Unwanted parasitic ground loop currents.
(D) Internal component self-heating effects.

2017

36. What is the fundamental principle behind a "guard circuit" in precision low-level measurements?
(A) It acts as a heavy physical metallic barrier that safely grounds all high-frequency electromagnetic signals.
(B) It automatically disconnects the input stage from the sensor if the measured voltage exceeds a safe threshold.
(C) It drives a guard conductor around the input node to the same potential, stopping leakage.
(D) It actively generates and introduces an inverse phase noise signal to cancel out common ambient interference.

NODIA

2022

37. Parasitic capacitance in signal cables can severely degrade system performance by acting as what type of filter?
(A) A low-pass filter, attenuating high-frequency signal components.
(B) A high-pass filter, blocking DC signals.
(C) A band-stop filter, eliminating 60 Hz noise automatically.
(D) An all-pass filter, creating non-linear phase shifts without attenuation.

2018

38. Which technique is most effective for mitigating the effects of parasitic capacitance in long cables used with high-impedance sensors?
(A) Using unshielded, loosely twisted signal wires.
(B) Sginificantly increasing the output impedance of the sensor.
(C) Lowering the power supply voltage rails of the acquisition system.
(D) Active guarding of the cable shield.

2021

39. In a first-order active low-pass filter using an operational amplifier, what determines the cut-off frequency?
(A) The physical gain-bandwidth product of the internal operational amplifier.
(B) Feedback resistor and capacitor values.
(C) The external DC power supply voltage rails applied to the active op-amp.
(D) The overall common-mode rejection ratio of the filter configuration.

2009

40. Consider the following statements regarding second-order active filters:
I. They exhibit a roll-off rate of -40 dB/decade.
II. They require exactly one resistor and one capacitor to set the frequency.
III. The Sallen-Key topology is a common implementation.
IV. They are incapable of providing signal gain.
Which of the above statements are correct?
(A) I, II and IV
(B) II and IV
(C) I and III
(D) I, III and IV

2004

41. What is the primary advantage of an active filter over a passive filter in signal conditioning?
(A) They operate passively without needing any external power supply rails.

(B) They possess high structural immunity to input high-voltage transients.
(C) They naturally provide perfect galvanic isolation between subsystems.
(D) They provide signal gain and minimize loading effects.

2005
42. A hardware-based analog linearization circuit is most likely to employ which of the following components to counteract a sensor's non-linear curve?
(A) A diode-resistor network for piecewise linear approximation.
(B) A basic voltage divider configuration utilizing high-precision metal film resistors.
(C) A high-speed digital microcontroller executing multi-term polynomial equations.
(D) An active bandpass filter with extremely high selectivity and Q factor.

2006
43. Why is signal offsetting often required before amplifying a bridge circuit's output?
(A) To significantly extend the upper frequency response limits of the bridge.
(B) To nullify the initial output so only the change is amplified.
(C) To convert the balanced differential signal into an unbalanced single-ended signal.
(D) To supply the highly stable excitation reference voltage to all bridge elements.

2003
44. Digital linearization algorithms typically utilize which of the following mathematical techniques?
(A) Fourier transforms and auto-correlation
(B) Polynomial curve fitting and look-up tables
(C) Sallen-Key filtering and integration
(D) Pulse-width modulation and synchronous demodulation

2011
45. In industry, why is the 4-to-20 mA current loop standard preferred over 0-10V voltage transmission for long distances?
(A) It is immune to voltage drops over long lines.
(B) It simplifies wiring by requiring only a single signal line plus a return.
(C) It is a fully passive system operating without any external power source.
(D) It naturally filters out low-frequency $\frac{1}{f}$ flicker noise components.

2024
46. What does a 4 mA signal signify in a standard 4-to-20 mA current loop?
(A) A broken wire or sensor failure.
(B) The maximum full-scale measurement value.
(C) The minimum measurement (live zero).
(D) A short circuit in the transmission line.

2015
47. A circuit designed to translate a 0-to-10V analog signal into a 4-to-20mA signal is functioning as a:
(A) Current-to-Voltage converter (Transimpedance amplifier)
(B) Galvanically isolated signal amplifier
(C) High-speed digital-to-analog converter
(D) Voltage-to-Current converter

2013
48. What is the primary purpose of an isolated current transmitter in a 4-to-20mA loop?
(A) To boost the current from 20 mA up to 100 mA to enable transmission over extremely long distances.
(B) To convert the baseline DC current into a high-frequency AC carrier signal for transmission.
(C) To break the galvanic path, preventing ground loops.
(D) To provide the highly regulated 24V DC excitation power supply required by the current loop.

2021
49. The fundamental operating principle of a thermocouple is based on which physical phenomenon?
(A) The Peltier effect
(B) The Seebeck effect
(C) The Hall effect
(D) The Piezoelectric effect

2014
50. Consider the following statements regarding Cold-Junction Compensation (CJC) in thermocouples:
I. CJC is necessary because a thermocouple measures absolute temperature directly.
II. CJC involves measuring the ambient temperature at the connection terminals.
III. CJC subtracts the ambient temperature voltage to correct the reading.
IV. CJC is only required for Type K thermocouples.
V. CJC can be performed using a thermistor or an IC temperature sensor.

Click Here to Buy book on Flipkart

Which of the above statements are INCORRECT?
(A) II, III and V
(B) I, II and IV
(C) II and V
(D) I and IV

2015

51. Why is isolated measurement frequently required for thermocouples used in industrial furnaces?
(A) The tip is often welded to grounded, high-voltage structures.
(B) Thermocouples inherently generate significant levels of high-frequency AC electrical noise.
(C) Thermocouples require a very high external reference excitation voltage that must be isolated.
(D) The Seebeck coefficient of the junction is altered by the presence of common-mode voltages.

2021

52. What is the primary advantage of converting a thermocouple voltage into a frequency signal (T-to-F conversion) near the measurement point?
(A) It significantly increases the physical thermal sensitivity of the thermocouple junction.
(B) It completely eliminates any requirement for active cold-junction compensation.
(C) Frequency signals are highly immune to amplitude noise.
(D) It inherently linearizes the non-linear thermocouple temperature-to-voltage response curve.

2021

53. In a 3-wire RTD (Resistance Temperature Detector) configuration, what is the specific purpose of the third wire?
(A) To enable compensation for lead-wire resistance.
(B) To supply a secondary auxiliary reference excitation voltage.
(C) To provide a solid earth ground reference path for cable shielding.
(D) To create a balanced differential output signal for noise immunity.

2014

54. Which of the following defines the typical resistance-temperature relationship of a standard Platinum RTD (e.g., PT100)?
(A) Highly non-linear, following the complex Steinhart-Hart equation.
(B) Exponentially decreasing electrical resistance with increasing sensor temperature.
(C) A sharp step-function change occurring at a specific critical temperature point.
(D) Relatively linear, with a positive temperature coefficient.

2025

55. Lead-wire resistance compensation in a 3-wire RTD bridge requires which condition to be effective?
(A) The third wire must have zero resistance.
(B) All three lead wires must have equal resistance.
(C) The RTD must have a negative temperature coefficient.
(D) The bridge must be excited with an AC voltage.

2019

56. What is the role of an RTD analog linearization circuit?
(A) To convert the RTD output directly into a standard 4-to-20mA current loop signal.
(B) To amplify the low-level RTD analog signal to a standard 0-to-10V measurement range.
(C) To correct the non-linear bow in the resistance curve.
(D) To mathematically solve the multi-term Callendar-Van Dusen equation in real-time.

2003

57. Thermistors are generally characterized by which of the following?
(A) A highly linear and predictable resistance-temperature relationship across all ranges.
(B) A relatively low sensitivity to temperature changes compared to standard thermocouples.
(C) The active generation of an output voltage proportional to a local thermal gradient.
(D) A non-linear, typically negative temperature coefficient.

2017

58. The non-linear response of a thermistor is mathematically modeled most accurately by which equation?
(A) The Steinhart-Hart equation
(B) The Callendar-Van Dusen equation
(C) The Seebeck polynomial
(D) The Maxwell-Boltzmann distribution

2018

59. When using a simple voltage divider to measure a thermistor, placing a fixed resistor in series with the thermistor serves to:

Downloaded from www.pdf.tube

(A) Perfect the overall absolute measurement accuracy of the sensor down to 0.01°C.
(B) Provide a narrow, roughly linear voltage output range.
(C) Completely eliminate any possibility of measurement errors due to self-heating.
(D) Prevent the high-impedance thermistor from picking up ambient 60 Hz electrical noise.

2003

60. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Thermistors are highly preferred for high-resolution differential thermometers measuring small temperature changes over a narrow range.
Reason (R): Thermistors possess an extremely high sensitivity (large change in resistance per degree Celsius) compared to RTDs and thermocouples.
In light of the above statements, choose the correct answer from the options given below:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019

61. Thermistor-to-frequency conversion circuits are often utilized to:
(A) Transmit data robustly over an optical isolator.
(B) Significantly increase the effective analog bandwidth of the sensing element.
(C) Induce localized self-heating effects deliberately to measure high-velocity fluid flow.
(D) Convert the standard negative NTC behavior into a positive PTC temperature response.

2022

62. Semiconductor temperature sensors operate based on the predictable temperature dependence of which parameter?
(A) The resistance of a thin-film platinum wire.
(B) The dielectric constant of a ceramic capacitor.
(C) The forward voltage drop of a PN junction.
(D) The magnetic permeability of a ferrite core.

2001

63. In a typical PN junction temperature sensor driven by a constant forward current, the voltage changes with temperature at a rate of approximately:
(A) -2 mV / °C
(B) -100 μV / °C
(C) +10 mV / °C
(D) +50 mV / °C

2018

64. What is the key characteristic of an absolute temperature-to-current converter (such as the AD590)?
(A) It generates an output current strictly proportional to the Celsius temperature.
(B) It uses a passive high-resolution thermistor network combined with a linear voltage divider.
(C) It outputs a current that is directly proportional to absolute temperature in Kelvin.
(D) It converts a standard 4-to-20mA signal back into a temperature reading.

NODIA

2013

65. T-to-F (Temperature-to-Frequency) conversion using diodes generally involves placing the diode in which part of an oscillator circuit?
(A) In parallel across the primary DC power supply rails.
(B) In the loop determining charging current.
(C) In series directly with the final digital output buffer stage.
(D) As a protective flyback suppression diode connected across an inductive relay.

2025

66. In data acquisition, what is the function of a multiplexer?
(A) To amplify multiple weak analog sensor signals simultaneously without crosstalk.
(B) To completely isolate the remote sensor grounds from the main measurement system.
(C) To convert a single high-speed digital stream into multiple separate analog outputs.
(D) To sequentially route multiple analog inputs to one device.

2010

67. Isolated multiplexing of thermocouples is necessary to prevent which specific issue?
(A) Cross-talk from shared grounds on different electrical potentials.
(B) Severe signal aliasing caused by excessively low channel sampling rates.

(C) The gradual physical depletion of the Seebeck voltage effect over time.
(D) Any requirement for active solid-state cold-junction compensation.

2015
68. All-electronic multiplexed applications using solid-state switches often suffer from which disadvantage compared to mechanical relays?
(A) Slower switching speeds.
(B) Higher power consumption.
(C) ON-resistance and leakage currents.
(D) Inability to be controlled by digital logic.

2025
69. Cross-talk reduction in analog multiplexers can be achieved by employing which of the following techniques?
(A) Grounding unused channels and lowering source impedance.
(B) Using low-cost unshielded cables for all analog input channels.
(C) Increasing the channel sampling frequency to its maximum hardware limit.
(D) Removing the protective guard rings surrounding the analog input pins.

2001
70. Match the sensor types in List I with their corresponding fundamental characteristics in List II.
List I: (Sensor Type)
P. Thermocouple
Q. RTD
R. Thermistor
S. PN Junction Diode
List II: (Fundamental Characteristic)
1. -2 mV/°C linear forward voltage response
2. Self-generating voltage based on thermal gradients
3. Highly non-linear NTC resistance change
4. Linear PTC resistance change, often requires 3-wire setup
Choose the correct answer from the options given below:
(A) P-1, Q-4, R-3, S-2
(B) P-2, Q-4, R-3, S-1
(C) P-2, Q-3, R-1, S-4
(D) P-3, Q-2, R-4, S-1

2001
71. Strain gauge signal conditioning primarily utilizes which circuit configuration to detect micro-strain changes?
(A) An inverting amplifier
(B) A Wheatstone bridge
(C) A precision peak detector
(D) A phase-locked loop

2019
72. In a potentiometer-to-frequency circuit used for position or pressure sensing, the potentiometer typically acts as what component in the oscillator?
(A) The primary stable voltage reference source.
(B) The high-value capacitive coupling element.
(C) The timing resistor in the RC network.
(D) The high-speed digital frequency divider stage.

2012
73. High-level semiconductor pressure transducers differ from basic strain gauges primarily because they:
(A) Do not utilize the physical piezoresistive effect within their sensing element.
(B) Require external, high-precision thermal cold-junction compensation.
(C) Can only measure absolute environmental pressure, completely excluding gauge pressure.
(D) Include integrated signal conditioning for high-level outputs.

2003
74. Sioated pressure control systems are vital in explosive environments (intrinsic safety) because isolation:
(A) prevents sparks from electrical faults in hazardous areas.
(B) significantly increases the structural burst strength of the internal pressure diaphragm.
(C) eliminates potential pneumatic and hydraulic pressure leaks in the lines.
(D) increases the communication speed of the digital field bus.

2023
75. Spring-driven rheostat circuits in force measurement convert mechanical displacement into:
(A) a changing capacitance
(B) a changing resistance
(C) a proportional digital word
(D) a varying magnetic field

2003
76. Interfacing a high-resolution load cell platform usually requires which combination of signal conditioning blocks?
(A) An active high-pass analog filter combined

Click Here to Buy book on Amazon

with a high-bandwidth transimpedance amplifier stage.
(B) Precision excitation, an instrumentation amplifier, and a low-pass filter.
(C) A high-performance chopper-stabilized amplifier paired with a current-to-voltage converter.
(D) A precision diode bridge rectifier followed by a low-drift active integrating circuit.

2006
77. Converting a strain-gauge output to a frequency signal is highly advantageous when:
(A) High-frequency electromagnetic noise must be completely filtered using active analog integrators.
(B) The signal must be transmitted over long distances in noisy environments with high noise immunity.
(C) The strain gauge operates at extremely high temperatures where zero drift is negligible.
(D) The system requires high-voltage galvanic isolation without any optoelectronic components.

2007
78. Differential Pressure (DP) flow meters measure flow rate based on which physical principle?
(A) Faraday's classical electromagnetic law of mutual induction.
(B) The high-frequency acoustic or optical Doppler frequency shift.
(C) Bernoulli's principle, relating pressure drop to flow rate squared.
(D) The physical Coriolis inertial force acting on a symmetrically vibrating sensor tube.

2018
79. When signal conditioning a DP flow meter, what mathematical operation is often required to obtain a linear flow rate signal?
(A) Differentiation
(B) Integration
(C) Logarithmic amplification
(D) Square root extraction

2025
80. Consider the following statements regarding frequency-output flowmeters (such as turbine flowmeters):
I. The output frequency is directly proportional to the fluid velocity.
II. They require square root extraction to linearize the flow reading.
III. The signal is typically picked up using a magnetic sensor.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2017
81. A hinged vane flow meter typically uses which mechanism to convert vane deflection into an electrical signal?
(A) A high-frequency active ultrasonic transceiver.
(B) A rotary potentiometer or encoder.
(C) A welded low-voltage thermocouple junction.
(D) A custom-built micro-variable capacitor.

2005
82. Thermal (anemometer) flow meters require a signal conditioning circuit that:
(A) Measures the precise acoustic transit time of an emitted high-energy thermal pulse.
(B) Senses the periodic physical vortex shedding frequency generated behind a bluff body.
(C) Senses a highly uniform magnetic field strictly perpendicular to the fluid flow vector.
(D) Measures power needed to maintain a constant temperature difference.

2004
83. In float-driven potentiometer signal extraction for level sensing, the electrical output is directly proportional to:
(A) The position of the float.
(B) The specific density of the liquid being measured.
(C) The temperature of the fluid.
(D) The rate of flow into the tank.

2019
84. Optical level sensing circuits rely on which physical phenomenon to detect the presence of a liquid?
(A) The sudden structural change in electrical conductivity when liquid physically contacts the sensor tip.
(B) The physical attenuation and absorption of high-energy beta radiation passing through the fluid.
(C) Refractive index differences, altering total internal reflection.
(D) The measurable change in absolute capacitance between two parallel conductive plates.

NODIA

2014

85. Thermal level sensing circuits operate by detecting:

(A) The change in heat dissipation when submerged in liquid versus air.
(B) The highly localized infrared blackbody radiation emitted from the liquid surface.
(C) The thermodynamic boiling point temperature of the liquid stored inside the tank.
(D) The physical thermal expansion rate of a bimetallic strip floating on the liquid surface.

2001

86. Universal advanced transducer-to-frequency conversion is generally implemented using which core circuit building block?

(A) A high-efficiency synchronous buck converter regulator.
(B) A high-resolution delta-sigma digital-to-analog converter.
(C) A low-drift active electrostatic charge amplifier circuit.
(D) A Voltage-to-Frequency Converter (VFC).

2003

87. What is a key benefit of directly converting analog sensor outputs to frequency signals for digital integration?

(A) It completely eliminates the physical necessity for any post-assembly system calibration.
(B) A simple digital counter can act as the converter.
(C) It guarantees theoretical infinite measurement resolution completely independent of sample times.
(D) It active-guards the system to prevent any long-term physical sensor degradation over time.

2019

88. When interfacing a variable capacitance sensor (e.g., for level measurement), which signal conditioning method is commonly used?

(A) Connecting the variable capacitor directly into a standard balanced DC Wheatstone bridge.
(B) Measuring the minute, steady-state DC leakage current flowing continuously through the capacitor.
(C) Using an AC bridge or an oscillator circuit.
(D) Heating the sensing capacitor to measure and mathematically subtract its internal thermal drift.

2024

89. Which characteristic defines an ideal current source used for RTD excitation?

(A) Zero output impedance
(B) An infinitely high input impedance
(C) Zero voltage output
(D) Infinite output impedance

2011

90. Consider the following statements regarding guard circuits:

I. Guarding reduces the effect of leakage resistance.
II. Guarding involves driving a shield to ground potential.
III. Guarding requires an active buffer amplifier to drive the guard trace.
IV. Guard rings are placed around low-impedance nodes to prevent noise emission.

Which of the above statements are INCORRECT?

(A) II and IV
(B) I and III
(C) I, II and IV
(D) II, III and IV

2022

91. In a differential amplifier configuration, if the resistors are not perfectly matched, what is the primary degraded parameter?

(A) Slew rate
(B) The system CMRR
(C) Bandwidth
(D) Output voltage swing

2014

92. A chopper-stabilized amplifier minimizes $\frac{1}{f}$ noise by doing what?

(A) Actively filtering out all unwanted noise components using a simple passive RC high-pass filter network.
(B) Modulating the input to a high frequency, amplifying, and demodulating it.
(C) Utilizing purely solid-state mechanical switching arrays that inherently do not generate any $\frac{1}{f}$ noise.
(D) Digitally calculating and subtracting a predetermined fixed noise calibration constant from the output.

2002

93. When signal conditioning an AC variable reluctance sensor, what type of circuit is utilized to convert the AC output into a usable DC voltage?

Downloaded from www.pdf.tube

(A) A precision rectifier and low-pass filter
(B) An active differentiating op-amp configuration.
(C) A high-stability active constant current source.
(D) A high-speed chopper-stabilized amplifier.

2002

94. What is the effect of placing an isolation amplifier in a data acquisition system reading high-voltage batteries?
(A) It significantly increases the maximum common-mode input voltage safely presented to the ADC.
(B) It completely eliminates any structural requirement for analog anti-aliasing filter stages.
(C) It protects ADC electronics and breaks ground loops.
(D) It automatically linearizes the non-linear high-voltage battery discharge response curve.

2022

95. A Sallen-Key low-pass filter topology is an example of:
(A) A purely passive multi-stage resistor-capacitor filter network.
(B) An integrated high-frequency switched-capacitor filter architecture.
(C) An active voltage-controlled current source (VCCS) filter topology.
(D) A second-order active filter with an op-amp.

2013

96. How does the number of poles in an analog filter affect its roll-off rate in the stopband?
(A) Each pole adds 6 dB/decade to the stopband roll-off rate.
(B) Each pole adds 12 dB/decade to the stopband roll-off rate.
(C) Each pole adds 20 dB/decade (6 dB/octave) to the stopband roll-off rate.
(D) Each pole adds 40 dB/decade (12 dB/octave) to the stopband roll-off rate.

2007

97. In a bridge-based offsetting circuit, how is the offset typically adjusted?
(A) By dynamically altering the primary reference excitation voltage operating frequency.
(B) By adjusting a nulling potentiometer in one bridge arm.
(C) By switching the primary amplification stage directly into an inverting configuration.
(D) By replacing the variable sensing element with a highly stable reference capacitor.

2001

98. Why are 0-to-10V signals less preferred than 4-to-20mA signals in harsh industrial environments?
(A) 0-to-10V signals exhibit significantly slower physical propagation speeds through transmission cables.
(B) 0-to-10V configurations structurally require four separate transmission wires instead of two.
(C) High-resolution analog-to-digital converters are fundamentally unable to sample 0-to-10V signals.
(D) They are susceptible to wire voltage drops and EMI.

NODIA

2023

99. Which circuit block is fundamentally required in a thermocouple measurement system but not in an RTD measurement system?
(A) Cold-Junction Compensation (CJC)
(B) High-performance instrumentation amplifier
(C) Active low-pass anti-aliasing filter
(D) High-resolution analog-to-digital converter

2007

100. Consider the following statements about semiconductor temperature sensors:
I. They typically exhibit a linear output.
II. They operate based on the Steinhart-Hart equation.
III. They are well-suited for extremely high temperatures ($> 1000^{\circ}C$).
IV. They often require a constant excitation current.
V. An example is a forward-biased silicon diode.
Which of the above statements are correct?
(A) II, III and V
(B) I, II, IV and V
(C) I, IV and V
(D) I, III, IV and V

2012

101. To measure gauge pressure, a pressure transducer must be referenced to:
(A) The local atmospheric pressure
(B) A perfect vacuum
(C) The pressure of a sealed internal reference chamber
(D) Absolute zero temperature

2023

102. What defines the sensitivity of a load cell?

(A) The maximum structural load weight it can support before experiencing physical damage.
(B) The nominal internal electrical resistance of its integrated strain gauge bridge.
(C) The natural fundamental frequency of its structural mechanical resonance.
(D) The ratio of full-scale output to excitation voltage.

2022

103. Which signal conditioning technique is critical for dealing with the very small (millivolt level) outputs of standard load cells?
(A) High-frequency electrostatic active charge amplifiers.
(B) Low-drift Instrumentation Amplifiers
(C) Highly stable, direct current-to-voltage conversion networks.
(D) Non-linear high-dynamic-range logarithmic compression amplifiers.

2017

104. In an isolated multiplexed data acquisition system, what component provides the galvanic barrier for the digital control signals?
(A) Instrumentation amplifiers
(B) Mechanical relays
(C) Optocouplers
(D) Low-pass filters

2014

105. A 4-to-20mA transmitter that is "loop-powered" draws its operating power from:
(A) An internal battery
(B) A local 120V AC wall outlet
(C) A separate dedicated 5V power cable
(D) The 4-to-20mA current loop itself

2010

106. When scaling an analog signal, if a sensor outputs -5V to +5V and the ADC accepts 0V to 3.3V, the signal conditioning circuit must perform:
(A) Attenuation and DC level shift
(B) Amplification and integration
(C) Differentiation and rectification
(D) Phase modulation and demodulation

2004

107. The cut-off frequency (f_c) of a simple RC low-pass filter is calculated using which formula?
(A) $f_c = R \times C$
(B) $f_c = \dfrac{1}{R \times C}$
(C) $f_c = \dfrac{2\pi}{RC}$
(D) $f_c = \dfrac{1}{2\pi RC}$

2019

108. What is the primary source of error when measuring an RTD with a 2-wire configuration?
(A) Parasitic thermoelectric voltages spontaneously generated at different metallic junctions.
(B) Unknown connecting lead-wire resistances adding to the measurement.
(C) Severe common-mode ground loop electrical interference originating from the main power supply.
(D) The inherent high-frequency quantization noise of the integrated analog-to-digital converter.

2002

109. Optical isolation is most effective at preventing which type of interference?
(A) Common-mode noise and ground loops.
(B) External low-frequency magnetic field interference.
(C) Temperature-induced physical thermal drift in the sensor element.
(D) Quantum-mechanical shot noise generated within the active active amplifier.

2009

110. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Current loop transmission (4-20mA) is highly immune to noise compared to voltage transmission.
Reason (R): Electromagnetic interference primarily induces voltage noise; because the receiver measures current, and the loop has a high impedance to induced voltage noise, the current remains unaffected.
In light of the above statements, choose the correct answer from the options given below:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2017

111. Which type of filter is specifically designed to provide a maximally flat amplitude response in the passband?
(A) Chebyshev response filter

Click Here to Buy book on Flipkart

(B) Bessel filter
(C) Elliptic filter
(D) Butterworth filter

2006
112. Why are Bessel filters often preferred for conditioning time-domain signals (like square waves or pulses)?
(A) They exhibit the sharpest possible frequency roll-off characteristics among all filter types.
(B) They structurally require the absolute minimum number of passive components to implement.
(C) They exhibit a linear phase response, minimizing distortion.
(D) They inherently provide the highest possible DC gain and signal-to-noise performance.

2011
113. A programmable-gain amplifier (PGA) allows a data acquisition system to:
(A) Automatically alter the reference excitation voltage supplied directly to the remote sensor element.
(B) Dynamically adjust amplifier gain to match input levels, maximizing ADC resolution.
(C) Reconfigure the internal digital resolution and sampling parameters of the analog-to-digital converter.
(D) Switch the active analog measurement channels between different types of sensors seamlessly.

2022
114. In a chopper-stabilized amplifier, what is the role of the low-pass filter at the output stage?
(A) To completely eliminate high-frequency random thermal Johnson noise from the sensing element.
(B) To provide adequate active anti-aliasing filtering prior to the analog-to-digital converter stage.
(C) To actively prevent common-mode voltage spikes from ever reaching the single-ended output terminal.
(D) To extract the DC signal by smoothing high-frequency ripples.

2010
115. Shielded twisted pair (STP) cabling is used in signal transmission to:
(A) Minimize shield-capacitive and twist-magnetic noise.
(B) Sginificantly increase the structural mechanical tensile strength of the transmission cable assembly.
(C) Provide a low-resistance path for high-current remote electrical power transmission.
(D) Completely eliminate any technical necessity for high-performance differential instrumentation amplifiers.

2003
116. In single-point grounding, all ground returns tie to a common point. What is the primary hazard of doing this incorrectly (e.g., daisy-chaining)?
(A) It completely eliminates necessary galvanic and optical isolation between subsystems.
(B) It causes the primary high-current power supply rails to experience a direct short circuit.
(C) Common impedance coupling causing signal interference.
(D) It inherently creates a massive loop antenna that captures high-frequency environmental RF noise.

2011
117. An op-amp used as a voltage follower (buffer) provides:
(A) Voltage gain of 1, high input impedance, and low output impedance
(B) Infinite voltage gain
(C) Voltage gain of -1, low input impedance, and high output impedance
(D) A logarithmic conversion of the input voltage

NODIA

2016
118. Which statement correctly describes the principle of cold-junction compensation in thermocouples?
(A) It mechanically or thermo-electrically refrigerates the physical reference junction to exactly 0°C.
(B) It linearly amplifies the extremely low-level Seebeck voltage directly to a standard 0-to-10V analog range.
(C) It automatically reverses the physical polarity of the thermocouple wiring to cancel out long-term drift.
(D) Adding a voltage equivalent to cold-junction ambient temperature to the reading.

2003
119. A thermistor with a Negative Temperature Coefficient (NTC) will exhibit:
(A) An increase in resistance as temperature increases.
(B) A decrease in resistance as temperature increases.
(C) A constant resistance over a wide temperature

range.

(D) An output voltage that increases logarithmically with temperature.

2005

120. Match the bridge output conditions in List I with their corresponding states in List II.

List I: (Bridge Output Condition)

P. Bridge is Balanced

Q. One arm varies by ΔR

R. Two opposite arms vary by $+\Delta R$

S. Four arms vary (two $+\Delta R$, two $-\Delta R$)

List II: (State)

1. Output is linearly maximum, highly sensitive
2. Output voltage is zero
3. Quarter bridge output, slightly non-linear
4. Half bridge output, doubled sensitivity

Choose the correct answer from the options given below:

(A) P-2, Q-3, R-4, S-1

(B) P-1, Q-4, R-3, S-2

(C) P-3, Q-1, R-4, S-2

(D) P-2, Q-1, R-4, S-3

2005

121. The Common-Mode Rejection Ratio (CMRR) of an operational amplifier is mathematically expressed as:

(A) $20\log_{10}\left(\frac{A_{cm}}{A_d}\right)$

(B) $10\log_{10}(A_d \times A_{cm})$

(C) $A_d - A_{\{cm\}}$

(D) $20\log_{10}\left(\frac{A_d}{A_{cm}}\right)$

2004

122. In a 3-op-amp instrumentation amplifier, the first stage consists of:

(A) Two non-inverting buffers/amplifiers

(B) Two inverting amplifiers

(C) A differential amplifier and an integrator

(D) A summing amplifier and a differentiator

2023

123. The 'loading effect' is minimized when measuring voltage by ensuring that the measuring instrument's input impedance is:

(A) Much smaller than the Thevenin equivalent resistance of the source.

(B) Significantly greater than source Thevenin equivalent resistance.

(C) Equal to the Thevenin equivalent resistance of the source.

(D) Exactly zero ohms.

NODIA

2009

124. When using an optical isolator for analog signals, what technique is typically used to overcome the non-linear transfer characteristics of LEDs and phototransistors?

(A) Utilizing an extremely high operational power supply voltage to swamp non-linearities.

(B) Transmitting digital data using an isolated ADC before the optocoupler.

(C) Passing the incoming analog signal through a precision active logarithmic amplifier stage first.

(D) Sginificantly increasing the physical separation distance between the internal LED and phototransistor.

2013

125. Which type of analog-to-digital converter is most commonly paired with extremely low-level sensors (like thermocouples and load cells) due to its high resolution and inherent low-pass filtering capabilities?

(A) Sigma-Delta $(\Sigma - \Delta)$ ADC

(B) Flash ADC

(C) Successive Approximation Register (SAR) ADC

(D) Pipelined ADC

2006

126. What is the fundamental mechanism that allows a transformer-coupled isolation amplifier to pass DC or very low frequency signals?

(A) The deliberate use of massive iron toroidal cores designed to maintain constant magnetic flux.

(B) Direct physical routing of a microscopic, high-resistance feedback wire directly through the core.

(C) Modulating the signal onto a high-frequency carrier.

(D) Actively exploiting the solid-state Hall effect sensor element within the internal transformer gap.

2007

127. A bridge excitation technique that rapidly turns the excitation voltage on and off is known as:

(A) Constant current excitation

(B) Phase-shifted excitation

(C) Auto-zeroing

(D) Pulsed-mode excitation

2023

128. What is a significant advantage of pulsed-mode bridge excitation in battery-powered IoT sensor nodes?

(A) It increases the bandwidth of the measurement.
(B) It boosts the excitation voltage above the battery voltage without a boost converter.
(C) It significantly reduces average power consumption and sensor self-heating.
(D) It inherently removes the need for an instrumentation amplifier.

2002

129. If a long signal cable acts as a low-pass filter due to parasitic capacitance, what is the consequence for a fast-changing (high-frequency) sensor signal?

(A) The fast-changing sensor signal is actively amplified by parasitic resonance.
(B) It experiences amplitude attenuation and phase shift.
(C) The fast-changing sensor signal remains completely unaffected by cable capacitance.
(D) The fast-changing sensor signal is completely blocked regardless of its actual frequency.

2015

130. Consider the following statements regarding current loop transmission:

I. It is highly susceptible to voltage drops along the line.
II. It only utilizes the 4-to-20 mA standard for legacy systems.
III. It can power the remote sensor directly using the loop current.

Which of the above statements is/are correct?

(A) I and II
(B) I and III
(C) II
(D) III

2010

131. In a differential pressure flow meter system, if the flow rate doubles, the measured differential pressure:

(A) Halves
(B) Remains constant
(C) Doubles
(D) Quadruples

2021

132. The "live zero" (4 mA) in a 4-to-20 mA current loop allows the system to distinguish between a genuine zero-level measurement and:

(A) a saturated sensor
(B) a ground loop
(C) a broken wire
(D) a common-mode transient

2013

133. Which linearizing element is commonly used in hardware analog linearization circuits for RTDs?

(A) A feedback loop with a multiplier or diode network.
(B) A purely capacitive low-leakage feedback network configuration.
(C) An integrated high-frequency magnetic step-up transformer.
(D) A high-speed asynchronous digital logic gate array.

2003

134. A frequency-output flowmeter (e.g., turbine meter) directly interfaces best with which type of digital acquisition component?

(A) A high-resolution ADC
(B) A digital-to-analog converter (DAC)
(C) An analog comparator
(D) A digital counter/timer input

2010

135. Which of the following is the primary operating principle of an ultrasonic level sensor?

(A) Measuring the transit time of a high-frequency sound wave reflected off the liquid surface.
(B) Senses the change in electrical capacitance of the fluid as the level rises.
(C) Detecting the hydrostatic pressure at the bottom of the container.
(D) Measuring the change in refractive index of the air-liquid boundary.

2015

136. When conditioning signals from a piezoelectric sensor, a "charge amplifier" is primarily used because:

(A) It converts the electrical charge into a voltage while eliminating cable capacitance effects.
(B) It increases the low output impedance of the sensor to prevent signal attenuation over distance.
(C) It provides a high excitation voltage to stabilize the sensor's internal capacitive structure.
(D) It rectifies the high-frequency AC current into a stable DC signal for standard analog inputs.

Downloaded from www.pdf.tube

2005

137. Which type of interference is generated by the presence of 50/60 Hz AC power lines near signal cables?

(A) Shot noise generated by active semiconductor junctions

(B) Electromagnetic interference from nearby power lines

(C) Thermal noise produced by resistive sensor components

(D) Flicker noise showing $\frac{1}{f}$ spectral density behavior

2016

138. Twisted pair wiring primarily reduces which type of noise coupling?

(A) Electrostatic (capacitive) coupling

(B) Magnetic (inductive) coupling

(C) Direct galvanic (resistive) coupling

(D) High-frequency conducted emissions

2005

139. What does the term "auto-zeroing" mean in the context of precision operational amplifiers?

(A) The periodic measurement and subtraction of internal offset voltage to minimize drift.

(B) The automatic disconnection of power when the input signal falls below a minimum threshold.

(C) The reduction of amplifier gain to zero to prevent signal saturation during high-noise events.

(D) The grounding of output terminals to prevent voltage spikes when transitioning between active states.

2006

140. Consider the following statements regarding the instrumentation amplifier (INA):

I. An INA is constructed using a single op-amp.

II. The gain of an INA is set by a single internal or external resistor.

III. An INA provides very low input impedance to drain noise currents.

IV. An INA is optimized for high common-mode rejection.

Which of the above statements are INCORRECT?

(A) I and III

(B) I, II and IV

(C) II and IV

(D) II, III and IV

2017

141. Strain gauges convert mechanical strain into a change in:

(A) Capacitance

(B) Inductance

(C) Magnetic permeability

(D) Electrical resistance

2021

142. The "gauge factor" of a strain gauge relates:

(A) The ratio of applied excitation voltage to the resulting output current loop.

(B) The change in environmental temperature to the baseline gauge resistance value.

(C) The fractional change in electrical resistance to the applied physical strain.

(D) The nominal physical length of the sensing element to its total capacitance.

2004

143. Why is it essential to compensate for temperature variations when using strain gauges?

(A) Extreme temperatures can physically melt or degrade the adhesive backing of the sensing element.

(B) Temperature variations change gauge resistance and base dimensions, creating apparent strain.

(C) Most standard gauges are calibrated to function within highly restricted thermal ranges near 25°C.

(D) Thermal fluctuations directly modify the excitation voltage requirements of the bridge circuit.

NODIA

2025

144. In a Wheatstone bridge utilizing strain gauges, how is temperature compensation inherently achieved?

(A) By utilizing a high-frequency pulsed-mode excitation sequence to minimize continuous thermal loading.

(B) By implementing external thermoelectric cooling systems to maintain a constant temperature profile.

(C) By replacing the constant DC excitation voltage with a balanced AC carrier frequency excitation.

(D) By placing an unstrained dummy gauge under identical thermal conditions in an adjacent bridge arm.

2011

145. A potentiometer used as a position sensor operates on the principle of a:

(A) Voltage divider

(B) Current divider
(C) Frequency modulator
(D) Phase shifter

2001

146. Which characteristic of an ideal operational amplifier allows the assumption that no current flows into its input terminals?
(A) Infinite open-loop gain
(B) Zero output impedance
(C) Infinite input impedance
(D) Infinite bandwidth

2011

147. A 4-wire measurement configuration (Kelvin connection) is essential when measuring:
(A) Extremely low resistance values
(B) Exceptionally high voltage levels
(C) High operational signal frequencies
(D) Very large capacitive load circuits

2008

148. How does a 4-wire (Kelvin) resistance measurement eliminate the error caused by lead wire resistance?
(A) By using specialized superconducting cables with near-zero internal resistance.
(B) By executing an automated calibration routine to measure and subtract lead wire effects.
(C) By applying a high-frequency AC current source and analyzing the resulting phase shift.
(D) By separating the current-carrying wires from the voltage-sensing wires across the resistor.

2018

149. The conversion of a thermocouple signal to frequency is often done using a:
(A) Frequency-to-Voltage Converter (FVC)
(B) Voltage-to-Frequency Converter (VFC)
(C) Phase-Locked Loop (PLL)
(D) Digital-to-Analog Converter (DAC)

2004

150. Consider the following statements about signal-to-noise ratio (SNR):
I. It is the ratio of signal power to noise power.
II. It is typically expressed in decibels (dB).
III. A high SNR means the signal is heavily corrupted by noise.
IV. Improving grounding and shielding can increase SNR.
V. SNR is irrelevant in digital signal processing.
Which of the above statements are correct?
(A) I, II and IV
(B) I, III and V
(C) II, IV and V
(D) I, II, III and IV

2001

151. Which device is primarily used to isolate a high-voltage industrial signal from a low-voltage data acquisition board while transmitting an analog signal?
(A) A simple voltage divider
(B) A Zener diode barrier
(C) An inverting operational amplifier
(D) An isolation amplifier

2003

152. In a grounded thermocouple, the measurement junction is physically welded to the protective metal sheath. What is a major disadvantage of this?
(A) Increased susceptibility to ground loops and noise.
(B) A significant reduction in the sensor's thermal response rate.
(C) Complete inability to measure extremely high temperature ranges.
(D) A mandatory requirement for an AC carrier excitation voltage source.

2009

153. A 0-to-10V analog signal requires transmission over 500 meters in a noisy factory. Which conditioning step should be taken?
(A) Boost the signal to 0-100V.
(B) Convert the signal to a 4-20mA current loop.
(C) Use unshielded wires to reduce parasitic capacitance.
(D) Add a large series resistor to the output.

2009

154. What is the main purpose of guard rings on a printed circuit board for high-impedance amplifiers?
(A) To provide physical mechanical reinforcement and secure the delicate amplifier package to the board.
(B) To intercept surface leakage currents by driving a surrounding trace to the node's potential.
(C) To act as a dedicated thermal heatsink for preventing junction temperature drift in the amplifier.
(D) To establish a low-impedance path to the primary chassis ground for all external shielding cables.

Click Here to Buy book on Amazon

2023

155. A constant current source used to excite a remote RTD is advantageous because:
(A) The current remains stable, reducing voltage drop errors caused by long lead wires.
(B) It completely eliminates self-heating errors by maintaining a low, constant temperature.
(C) It modifies the RTD's physical properties to match those of a standard active thermocouple.
(D) It removes any necessity for external cold-junction temperature compensation circuits.

2001

156. In an ideal op-amp integrating circuit, the feedback component is:
(A) A resistor
(B) An inductor
(C) A capacitor
(D) A diode

2004

157. A differentiating op-amp circuit uses which component at its input?
(A) A resistor
(B) An inductor
(C) A diode
(D) A capacitor

2022

158. The process of modifying a non-linear sensor output to produce a direct proportional relationship with the measured variable is called:
(A) Demodulation
(B) Amplification
(C) Linearization
(D) Isolation

2001

159. When multiplexing multiple thermocouples into a single ADC, where should the cold-junction compensation (CJC) sensor be located?
(A) Directly at the active hot junction of each individual thermocouple probe.
(B) On the isothermal terminal block transitioning to copper traces.
(C) Within the internal silicon architecture of the main system ADC chip.
(D) Near the central power regulation module of the data acquisition board.

2001

160. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Hardware-based analog linearization circuits are becoming less common in modern instrumentation.
Reason (R): High-resolution microcontrollers and ADCs can easily perform digital linearization using lookup tables or polynomial equations, offering greater flexibility.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2018

161. An instrumentation amplifier's high CMRR is most effective at rejecting noise that is:
(A) Common-mode noise present equally on both inputs.
(B) Differential-mode noise present between the inputs.
(C) High-frequency electromagnetic noise from external sources.
(D) Thermal noise internally generated within the amplifier stages.

2024

162. The use of a "dummy" strain gauge in a Wheatstone bridge primarily compensates for:
(A) Non-linear strain effects occurring at high load levels.
(B) Fluctuations and drift in the bridge excitation voltage source.
(C) Thermal resistance changes in the active gauge.
(D) Low-frequency voltage drift in the instrumentation amplifier.

NODIA

2012

163. The primary reason for utilizing an anti-aliasing filter before an ADC is to:
(A) Block frequencies above half the sampling rate to prevent aliasing.
(B) Amplify weak analog inputs to match the full scale of the ADC converter.
(C) Establish reliable galvanic isolation between the sensor and host computer.
(D) Filter out any unwanted low-frequency DC offsets or drift from the signal.

2004

164. What type of filter is an anti-aliasing filter?
(A) High-pass filter
(B) Band-pass filter
(C) Notch filter
(D) Low-pass filter

2008

165. A 50/60 Hz notch filter is specifically designed to:
(A) Block all DC drift and ultra-low-frequency thermal drift components.
(B) Attenuate AC power line noise while passing surrounding frequencies.
(C) Pass only high-frequency electromagnetic and radio frequency signals.
(D) Correct the non-linear resistance-temperature curve of a thermistor.

2003

166. Which type of sensor would most likely use an optical level sensing circuit?
(A) A strain gauge load cell
(B) A differential pressure flow meter
(C) A liquid point-level detector
(D) A continuous float level sensor

2019

167. An RTD is made from platinum primarily because:
(A) It is highly cost-effective, durable, and widely available in commercial markets.
(B) It exhibits a highly pronounced negative temperature coefficient across all ranges.
(C) It generates a robust and easily measurable thermoelectric Seebeck voltage output.
(D) It offers an exceptionally stable resistance-temperature relationship.

2021

168. If the reference junction of a thermocouple is NOT maintained at exactly 0°C, what compensation is required?
(A) Cold-Junction Compensation (CJC)
(B) Adding an instrumentation amplifier
(C) Replacing the thermocouple with an RTD
(D) Shielding the thermocouple wire

2024

169. What does the "Cold-Junction" refer to in a thermocouple circuit?
(A) The physical location where the target process temperature is being measured.
(B) The junction where thermocouple alloys connect to copper system traces.
(C) A highly stabilized physical ice bath required to keep temperature at zero.
(D) The surrounding protective metallic shield of the sensor transmission cable.

2024

170. Match the flow meter type in List I with its operating principle in List II:
List I: Flow Meter Type
P. Differential Pressure
Q. Turbine (Frequency)
R. Thermal Mass
S. Hinged Vane
List II: Operating Principle
1. Detects heat transfer rate to the fluid
2. Measures pressure drop across a restriction
3. Fluid turns a rotor generating pulses
4. Mechanical displacement measured by a potentiometer
(A) P-2, Q-3, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

2003

171. A signal conditioning circuit that transforms an unknown input voltage into a proportional output current is known as a:
(A) Voltage-controlled current source (VCCS)
(B) Current-controlled voltage source (CCVS)
(C) Current mirror
(D) Charge amplifier

2005

172. The term "excitation" in sensor interfacing refers to:
(A) The raw output signal generated by the active sensing element under test.
(B) The specialized process of filtering out high-frequency electromagnetic noise.
(C) External power supplied to a passive sensor to generate an output signal.
(D) The systematic baseline calibration of the physical sensor instrumentation.

2002

173. Which of the following sensors requires external excitation?
(A) Thermocouple
(B) Photovoltaic cell
(C) Piezoelectric accelerometer
(D) Strain gauge

2008

174. Which of the following sensors generates its own voltage and does NOT require external excitation?
(A) RTD
(B) Thermistor
(C) Thermocouple
(D) Potentiometer

Downloaded from www.pdf.tube

2011

175. When conditioning a signal from an RTD over a long distance, a 4-wire configuration is preferred over a 3-wire because:
(A) It provides significantly higher mechanical and structural durability.
(B) It eliminates errors from mismatched lead-wire resistances.
(C) It requires far less total electrical power during active excitation.
(D) It inherently suppresses high-frequency electromagnetic interference.

2010

176. What is the fundamental role of an ADC in an instrumentation system?
(A) To convert discrete digital numbers into continuous analog voltages.
(B) To amplify small sensor signals.
(C) To provide excitation to Wheatstone bridges.
(D) To convert continuous analog voltages into discrete digital numbers.

2007

177. A transducer with an output range of 0 to 50 mV is to be connected to an ADC with an input range of 0 to 5 V. What is the required gain of the signal conditioning amplifier?
(A) 10
(B) 50
(C) 100
(D) 1000

2023

178. What does "offsetting" a signal mean?
(A) Multiplying the input signal magnitude by a constant gain factor.
(B) Converting a continuous analog signal into discrete digital values.
(C) Adding or subtracting a constant DC level.
(D) Delaying the signal propagation through a hardware delay network.

2025

179. A sensor outputs a signal from -2V to +2V. The ADC requires a 0V to 5V input. What signal conditioning operations are required?
(A) Both gain adjustment and DC offsetting.
(B) Only signal amplification to scale amplitude.
(C) Only signal attenuation to compress amplitude.
(D) Both differentiation and signal integration.

2023

180. Which is the correct sequence of signal conditioning stages for a low-level sensor output in a typical digital data acquisition system?
(A) Sensor → ADC → Amplifier → Filter
(B) Sensor → Amplifier → Filter → ADC
(C) Sensor → Filter → ADC → Amplifier
(D) Sensor → ADC → Filter → Amplifier

NODIA

2011

181. "Aliasing" in a data acquisition system occurs when:
(A) Setting the amplifier gain excessively high, causing output signal clipping.
(B) Sampling at less than twice the signal's highest frequency.
(C) Having an analog-to-digital converter resolution that is far too low.
(D) Applying a common-mode voltage that exceeds the differential amplifier limits.

2018

182. Nyquist's sampling theorem states that to faithfully reconstruct a signal, it must be sampled at a rate:
(A) Equal to its maximum frequency.
(B) At half its maximum frequency.
(C) At least twice its maximum frequency.
(D) Exactly 10 times its maximum frequency.

2017

183. Which component of a data acquisition system determines its resolution (the smallest measurable change)?
(A) The overall high-frequency bandwidth of the input amplifier.
(B) The designated cut-off frequency of the low-pass filter stages.
(C) The total physical length and quality of the signal copper cables.
(D) The bit resolution of the system's internal ADC.

2001

184. A 12-bit ADC has an input range of 0 to 10V. What is its approximate resolution (voltage step size)?
(A) 1.22 mV
(B) 2.44 mV
(C) 4.88 mV
(D) 10.00 mV

2011

185. A "floating" signal source is defined as one that:
(A) Oscillates dynamically without any internal control feedback loop.

(B) Lacks any physical connection to absolute system ground.
(C) Is strictly categorized as a high-frequency AC voltage source.
(D) Requires physical immersion in a conductive liquid cooling bath.

2019

186. When connecting a floating signal source to a differential amplifier, what must be provided to prevent the amplifier inputs from drifting outside their common-mode range?
(A) A highly robust galvanic isolation barrier to handle transient spikes.
(B) A DC bias path to ground for input leakage currents.
(C) A high-capacitance non-polarized series coupling capacitor network.
(D) An active chopper-stabilized low-drift offset correction loop.

2010

187. The resistance of a typical NTC thermistor is governed by an exponential relationship. The constant characterizing this curve is called the:
(A) Beta (β) value
(B) Seebeck coefficient
(C) Gauge factor
(D) Piezoelectric constant

2003

188. Which of the following defines the "Seebeck coefficient"?
(A) The fractional change in electrical resistance per unit of mechanical strain.
(B) The temperature-dependent fractional change in baseline sensor resistance.
(C) The thermoelectric voltage generated per unit temperature difference.
(D) The proportional change in electrical capacitance per unit of liquid level.

2008

189. Which is the correct order of components in a 4-to-20mA current loop system?
(A) Sensor → Transmitter → Power Supply → Receiver
(B) Transmitter → Sensor → Receiver → Power Supply
(C) Receiver → Power Supply → Sensor → Transmitter
(D) Power Supply → Receiver → Transmitter → Sensor

2008

190. Consider the following steps of chopper amplification:
I. Synchronous demodulation back to DC
II. Modulation of low-frequency DC input to an AC carrier
III. Low-pass filtering to smooth the output
IV. Amplification using an AC-coupled amplifier
Which of the following represents the correct sequence of these steps?
(A) I, II, III, IV
(B) II, IV, I, III
(C) IV, I, II, III
(D) II, I, IV, III

2021

191. Galvanic isolation in signal conditioning means:
(A) The signal is actively amplified using an integrated galvanic battery cell.
(B) Signal transmission without direct ohmic connection between input and output.
(C) The delicate measuring circuit is enclosed in an grounded aluminum shield.
(D) The primary sensing element operates fundamentally on electrochemical reactions.

2024

192. Which technique allows a single isolation amplifier to handle multiple isolated sensor channels simultaneously without losing isolation?
(A) Routing all analog signals continuously through one high-speed optical isolator.
(B) Wiring all sensor outputs in a parallel configuration directly to the isolator.
(C) Accepting that single-isolator multi-channel configurations are physically impossible.
(D) Multiplexing the analog channels on the isolated side before amplification.

2003

193. The primary reason a high input impedance amplifier is required for a pH sensor is:
(A) pH sensors have extremely high source impedance, making them sensitive to current draw.
(B) pH sensors naturally produce exceptionally high output voltages on the scale of kilovolts.
(C) pH sensors depend on receiving a very high external excitation current to operate stably.
(D) High input impedance functions as an inherent passive filter for local chemical noise.

2022

194. A Wheatstone bridge relies on the concept of a "null" measurement. What does this mean?

Click Here to Buy book on Flipkart

(A) Actively monitoring the absolute peak voltage levels under maximum operational load.
(B) Permitting the internal circuitry to output random zero-voltage signals periodically.
(C) Balancing the bridge so the potential difference between output nodes is zero.
(D) Completely disabling or shutting down the active sensing element when it is idle.

2023

195. What is the fundamental difference between a full-bridge and a half-bridge strain gauge configuration?
(A) A full-bridge uses four active gauges, while a half-bridge uses only two.
(B) A full-bridge always requires double the baseline excitation voltage of a half-bridge.
(C) A half-bridge configuration is physically incapable of detecting compressive mechanical strain.
(D) A full-bridge network cannot be electrically structured within a standard Wheatstone layout.

2015

196. The purpose of a "voltage follower" in signal conditioning is to:
(A) Scale the incoming analog signal voltage by a precise multiplication factor of ten.
(B) Transform an analog input voltage level into a corresponding frequency pulse train.
(C) Trace dynamic input peaks and capture the maximum voltage level on a holding capacitor.
(D) Act as a high input impedance, low output impedance unity-gain buffer.

2010

197. Which of the following errors is NOT mitigated by an instrumentation amplifier (INA)?
(A) Common-mode noise from 60 Hz power lines.
(B) Differential-mode noise generated by the sensor itself.
(C) Ground loop potentials between the sensor and the measurement system.
(D) Loading effects on high-impedance sensors.

2011

198. In a 0-to-10V signal transmission system, a 1-volt drop occurs along the wire due to resistance. What is the resulting error at the receiver?
(A) No error, the receiver compensates automatically.
(B) The signal is completely lost.
(C) A 1-volt measurement error.
(D) The receiver interprets it as an over-range error.

2005

199. In the same scenario as the previous question, if a 4-to-20mA system is used and a 1-volt drop occurs across the wire resistance, what is the resulting error at the receiver?
(A) An immediate and proportional 1-mA current measurement error at the receiver.
(B) A persistent baseline 4-mA offset error across the entire operational range.
(C) Complete failure of the current loop circuit due to the added series resistance.
(D) No error, provided loop compliance voltage limits are not exceeded.

2006

200. What is a "compliance voltage" in the context of a 4-20mA current loop transmitter?
(A) The maximum voltage a transmitter can output to drive loop current.
(B) The minimum operating voltage required by the loop receiver module.
(C) The electrical breakdown rating of the copper wire insulation jacket.
(D) The nominal standard AC voltage delivered by the regional power grid.

2024

201. Which op-amp parameter describes its ability to reject variations in the power supply voltage?
(A) Gain-Bandwidth Product
(B) Power Supply Rejection Ratio
(C) Common-Mode Rejection Ratio
(D) Maximum Slew Rate Limit

2002

202. The "slew rate" of an operational amplifier limits:
(A) The absolute lowest operational signal frequency that the active amplifier can process.
(B) The maximum output voltage rate of change, limiting high-frequency performance.
(C) The parasitic input offset current mismatch between internal transistor base terminals.
(D) The peak DC voltage level that can be safely applied to the differential input ports.

2007

203. A low-pass filter with a cut-off frequency of 100 Hz will:
(A) Pass signals below 100 Hz and attenuate

Downloaded from www.pdf.tube

higher frequencies.
(B) Block all incoming signals below the designated 100 Hz threshold.
(C) Fully pass all signal frequencies starting above the 100 Hz limit.
(D) Serve as a complete open circuit for all low-frequency DC signals.

2019
204. "Cross-talk" in a multiplexed data acquisition system refers to:
(A) The physical routing of crossed signal wires inside the main shield.
(B) The voice communications exchanged between control room operations staff.
(C) Unwanted signal leakage between adjacent multiplexer channels.
(D) The digital synchronization timing pulses between multiplexer and ADC.

2007
205. Which technique minimizes cross-talk in an analog multiplexer?
(A) Maintaining the source impedance of all input channels at extremely high levels.
(B) Increasing the electronic multiplexer switching speed to near-infinite rates.
(C) Bundling all unshielded analog input cables tightly together over long runs.
(D) Using low source impedances and allowing adequate settling time.

2017
206. A "charge amplifier" used with piezoelectric sensors essentially converts charge (Q) into voltage (V) using a feedback capacitor (C_f). The basic equation is:
(A) $V = Q \times C_f$
(B) $V = \frac{C_f}{Q}$
(C) $V = -\frac{Q}{C_f}$
(D) $V = \frac{dQ}{dt}$

2019
207. Piezoelectric sensors are generally unsuitable for measuring:
(A) Dynamic high-frequency mechanical vibrations.
(B) Static forces or continuous DC pressures.
(C) Extremely fast-changing dynamic fluid pressures.
(D) Transient ultrasonic acoustic emission signals.

2003
208. What is the main advantage of a semiconductor strain gauge over a metallic foil strain gauge?
(A) It is perfectly linear over its entire range.
(B) It has virtually no temperature dependence.
(C) It can be stretched to twice its length without breaking.
(D) It has a much higher gauge factor (sensitivity).

NODIA

2025
209. To measure a very small resistance change (ΔR) in a strain gauge, the Wheatstone bridge output is typically connected to:
(A) An instrumentation amplifier.
(B) A high-impedance voltage follower.
(C) A high-pass differentiating circuit.
(D) An active analog peak detector.

2008
210. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): A low-pass filter is invariably placed immediately before an analog-to-digital converter.
Reason (R): It acts as an anti-aliasing filter to ensure no signal or noise components exceed the Nyquist frequency of the sampling system.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025
211. Which component provides cold-junction compensation in a typical modern thermocouple data acquisition module?
(A) An IC temperature sensor mounted on the connection block.
(B) A miniature electronic ice bath chamber integrated into the silicon.
(C) A secondary reference thermocouple of a complementary material type.
(D) A high-voltage galvanic isolation barrier protecting the ADC input.

2004
212. What defines an "isothermal" terminal block used for thermocouples?
(A) It actively generates internal thermal energy to maintain a constant 100°C.

(B) It is fabricated from special materials to be perfectly electrically conductive.
(C) It isolates the thermocouple junctions completely from the main system ground.
(D) It maintains all terminals at the same temperature to eliminate thermal gradients.

2003
213. Thermocouples are typically characterized by different letters (e.g., K, J, T). What do these letters represent?
(A) The physical length and diameter specifications of the probe.
(B) The alloy combination, determining temperature range and sensitivity.
(C) The specialized chemical composition of the wire outer insulation.
(D) The proprietary trademark of the original equipment manufacturer.

2011
214. Which thermocouple type consists of Chromel and Alumel alloys and is the most common general-purpose type?
(A) Type J
(B) Type T
(C) Type K
(D) Type S

2016
215. When connecting a thermocouple to a measurement device, extension wires must be made of:
(A) Pure high-purity copper to keep lead resistance to an absolute minimum.
(B) Solid silver wire due to its exceptionally high thermal conductivity rates.
(C) Standard commercial shielded twisted pair cable with braided grounding wires.
(D) The same alloys as the thermocouple to prevent unintended thermoelectric junctions.

2011
216. The Steinhart-Hart equation is specifically used to linearize the reading from which sensor?
(A) NTC Thermistor
(B) Thermocouple
(C) Platinum RTD
(D) Strain gauge

2010
217. A standard PT100 RTD has a resistance of what value at 0°C?
(A) 0 Ω
(B) 100 Ω
(C) 1000 Ω
(D) 10 kΩ

2014
218. When a high current is passed through an RTD for excitation, what measurement error is introduced?
(A) Signal aliasing due to low ADC sampling frequency.
(B) Self-heating error, raising the RTD temperature above ambient.
(C) Parasitic thermoelectric voltage offsets at the lead junctions.
(D) Output slew rate limiting within the signal conditioning block.

2018
219. To minimize self-heating in an RTD, the excitation current is typically kept in the range of:
(A) 100 μA to 1 mA
(B) 10 mA to 50 mA
(C) 100 mA to 500 mA
(D) A to 5 A

2006
220. Match the isolation technique in List I with its description in List II:
List I: Isolation Technique
P. Optical Isolation
Q. Magnetic/Transformer Isolation
R. Capacitive Isolation
S. Galvanic Isolation
List II: Description
1. Uses high-frequency modulation across an isolation barrier capacitor
2. General term for breaking direct DC electrical paths
3. Uses an LED and a phototransistor/ photodiode
4. Uses inductively coupled coils to transfer AC-modulated signals
(A) P-2, Q-4, R-1, S-3
(B) P-3, Q-4, R-1, S-2
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-2, R-3, S-4

2006
221. An isolation amplifier is crucial in medical instrumentation (like an ECG) primarily to:
(A) Optimize and broaden the overall frequency response of the raw ECG signal.
(B) Prevent the patient's body from inadvertently magnetizing the sensitive lead sensors.
(C) Perform high-resolution digitization of the analog signal directly at the chest electrode.

Click Here to Buy book on Amazon

(D) Protect the patient from hazardous electrical leakage currents.

2023

222. An AC-coupled amplifier is one that has:
(A) A high-Q magnetic inductor wired in series directly with the analog input terminal.
(B) A zero-ohm direct galvanic copper connection with minimal contact resistance.
(C) A series capacitor at the input that blocks DC and passes only AC signals.
(D) An active chopper-stabilized switching network to correct for internal DC offset.

2007

223. Why would AC coupling be used when measuring a small dynamic pressure ripple on top of a massive static pressure?
(A) To transform the baseline static pressure into a proportional high-frequency carrier wave signal.
(B) To block the large DC static offset, preventing saturation and enabling high AC gain.
(C) To supply continuous electrical operating power to the remote sensor using high-voltage AC mains.
(D) To actively filter out high-frequency thermal noise generated by the resistive sensor element.

2013

224. The Callendar-Van Dusen equation models the non-linear relationship of:
(A) A thermistor
(B) A thermocouple
(C) A PN junction diode
(D) An RTD

2005

225. What type of flowmeter relies on Faraday's law of electromagnetic induction?
(A) Magnetic flowmeter (Magmeter)
(B) Turbine flowmeter
(C) Differential pressure flowmeter
(D) Ultrasonic flowmeter

2024

226. A magnetic flowmeter can only be used to measure fluids that are:
(A) Chemically inert
(B) Fully gaseous
(C) Conductive
(D) Highly viscous

2009

227. In a differential pressure flow measurement, the flow rate (Q) is proportional to the differential pressure (ΔP) by which relationship?
(A) $Q \propto \sqrt{\Delta P}$
(B) $Q \propto \Delta P$
(C) $Q \propto (\Delta P)^2$
(D) $Q \propto \frac{1}{\Delta P}$

2010

228. "Square root extraction" in flow signal conditioning is necessary to:
(A) Filter out high-frequency 60 Hz AC power line noise.
(B) Prevent transient spikes from overflowing the system ADC.
(C) Convert a 4-20mA current loop signal back to a voltage level.
(D) Linearize the flow-to-pressure relationship.

2003

229. A variable reluctance sensor used for gear tooth speed detection generates what type of signal?
(A) A highly stable DC voltage with no frequency component.
(B) An AC voltage with frequency scaled to gear speed.
(C) A standard analog 4-to-20 mA current loop output signal.
(D) A high-speed digital pulse-width modulated (PWM) output.

2019

230. Which of the following is the correct sequence of operations in a typical Delta-Sigma ADC data acquisition system?
(A) Analog Input → Digital Filter → Delta-Sigma Modulator → Digital Output
(B) Analog Input → Delta-Sigma Modulator → Digital Filter/Decimator → Digital Output
(C) Analog Input → Integrator → Comparator → Delta-Sigma Modulator
(D) Analog Input → SAR Register → Modulator → Digital Output

NODIA

2023

231. The primary advantage of a Delta-Sigma ADC over a Successive Approximation Register (SAR) ADC is:
(A) Significantly faster sampling speed reaching the gigahertz region.
(B) A complete lack of requirement for analog signal conditioning blocks.
(C) Extremely low operational power consumption approaching zero.

(D) High resolution and built-in digital anti-aliasing.

2022

232. To detect the liquid level in a tank using a variable capacitance probe, the liquid must act as either the dielectric or:
(A) A conductive extension of one plate, changing the active area.
(B) The primary high-frequency AC voltage excitation source for the system.
(C) A highly permeable magnetic core that alters circuit inductance levels.
(D) An absolute physical optical barrier that blocks light-emitting diodes.

2025

233. Optical level sensors typically use a prism. When liquid covers the prism:
(A) Light undergoes complete internal reflection and returns directly to the optical receiver.
(B) Light refracts into the liquid because the external refractive index matches the prism.
(C) Light waves experience a pronounced frequency change due to the physical Doppler shift.
(D) Light energy is entirely absorbed by the fluid medium and converted into thermal energy.

2014

234. In force and load cell interfacing, a "spring-driven rheostat" is a legacy transducer that:
(A) Leverages advanced piezoresistive silicon to measure micro-level strain fields.
(B) Translates spring compression into a wiper's movement over a resistor.
(C) Outputs a highly stable AC frequency that scales linearly with applied force loads.
(D) Analyzes mechanical deformation through high-precision optical laser interferometry.

2012

235. A "load cell platform" typically utilizes multiple load cells (e.g., one at each corner). How are their signals usually combined?
(A) By summing parallel currents in hardware or processing separate ADC channels in software.
(B) By wiring all sensor outputs in series to multiply the cumulative output voltage levels.
(C) By feeding the individual signals directly into a dedicated analog mathematical multiplier.
(D) By implementing a complex mechanical linkage to concentrate all force onto a single load cell.

2007

236. A Voltage-to-Frequency Converter (VFC) integrates the input voltage and produces a pulse train. The frequency of this pulse train is:
(A) Inversely proportional to the input voltage.
(B) Proportional to the square of the input voltage.
(C) Directly proportional to the input voltage.
(D) Constant, acting only as a clock.

2019

237. When using a VFC for data transmission over a long distance, the main advantage is:
(A) It requires only a single unshielded signal conductor wire with no ground return loop.
(B) It establishes robust, high-voltage galvanic isolation across the transmission line.
(C) It significantly boosts and amplifies the baseline analog signal voltage level over distance.
(D) Frequency is unaffected by amplitude degradation, preserving measurement accuracy.

2010

238. In a VFC-based analog-to-digital conversion system, how is the final digital value obtained by the microcontroller?
(A) By processing the raw frequency input through a high-speed internal SAR ADC.
(B) By measuring the maximum peak voltage amplitude of each received pulse signal.
(C) By counting the incoming pulses over a defined, precise gating period.
(D) By routing the pulse train directly through a multi-stage digital low-pass filter.

2015

239. The resolution of a VFC-based ADC system is determined by:
(A) The absolute peak amplitude of the analog input excitation voltage source.
(B) The length of the counting time window, balancing resolution against sample rate.
(C) The total physical distance separating the signal transmitter and receiver units.
(D) The specific wire gauge and material composition of the transmission cable.

2011

240. Consider the following filtering steps in a typical precision DC measurement system:
I. Anti-aliasing active low-pass filter
II. RFI/EMI passive input filter

Downloaded from www.pdf.tube

III. Digital moving average filter (software)

Which of the following represents the correct sequence of these steps from the highest cutoff frequency to the lowest cutoff frequency?

(A) I, II, III
(B) II, I, III
(C) III, I, II
(D) II, III, I

2002

241. Shielding a cable is ineffective against magnetic interference unless:

(A) The shield uses high-permeability magnetic material or the wires are twisted.
(B) The outer shield is actively driven by a high-precision guard amplifier stage.
(C) The copper shield layer is terminated and grounded at both ends of the cable run.
(D) The shielding envelope is fabricated using high-purity solid gold laminates.

2016

242. Ground loops can be broken using all of the following EXCEPT:

(A) Optocouplers
(B) Transformers
(C) Coaxial cables with ungrounded shields
(D) Instrumentation amplifiers configured for differential measurement

2017

243. When terminating a shielded cable, where is the shield typically grounded to prevent ground loops?

(A) At a single end to avoid creating loop paths.
(B) At both the sensor housing and the receiver chassis points.
(C) At neither termination point, leaving the shield fully floating.
(D) At a single centralized connection point in the middle of the run.

2016

244. A "guard" in a low-level leakage measurement circuit is:

(A) A robust physical metallic enclosure designed to shield the entire measurement system.
(B) A high-level software threshold value configured to trigger automatic emergency shutdowns.
(C) A protective analog diode clamp network structured to prevent input overvoltage events.
(D) A low-impedance trace surrounding the input node, driven to its exact potential to stop leakage.

2009

245. Active guarding is particularly critical when interfacing with which type of sensor?

(A) A low-impedance active thermocouple sensor.
(B) A high-impedance pH probe.
(C) A standard 100-ohm platinum RTD sensor.
(D) A standard 4-to-20 mA current transmitter loop.

2024

246. What is the effect of parasitic capacitance in a piezoelectric sensor cable?

(A) It dramatically amplifies the high-frequency electromagnetic noise.
(B) It acts as a strict DC block, preventing any low-frequency measurement.
(C) It forms a capacitive divider with the sensor, attenuating the signal.
(D) It causes the physical cable assembly to resonate under mechanical loads.

2013

247. When using a voltage-mode amplifier instead of a charge amplifier with a piezoelectric sensor, the amplifier must be located as close to the sensor as possible because:

(A) Cable resistance would otherwise cause significant voltage drop.
(B) Cable capacitance would otherwise attenuate the measurement signal.
(C) Long cables act as high-pass filters that block high frequencies.
(D) High-frequency electromagnetic noise would otherwise rectify into DC.

NODIA

2007

248. The primary characteristic of a Butterworth filter is that it has:

(A) A maximally flat response in the passband.
(B) A very steep roll-off rate with high passband ripple.
(C) An exceptionally flat, linear phase response characteristic.
(D) A highly restricted, narrow stopband attenuation region.

2006

249. A first-order RC low-pass filter provides a roll-off of:

(A) -10 dB/decade
(B) -20 dB/decade
(C) -40 dB/decade
(D) -60 dB/decade

2018

250. To achieve a steeper roll-off of -40 dB/decade, an active filter must be at least:
(A) First-order
(B) Second-order
(C) Third-order
(D) Fourth-order

2004

251. Hardware linearization of an RTD circuit using positive feedback essentially:
(A) Modulates the excitation current to counteract the non-linear RTD curve.
(B) Boosts the dynamic gain of the instrumentation amplifier at high frequencies.
(C) Performs digital interpolation across a microchip-based look-up table.
(D) Translates the analog resistance variations into a stable square frequency.

2022

252. A piece-wise linear approximation circuit uses diodes to:
(A) Rectify external high-frequency AC noise components from the sensor lines.
(B) Generate a highly precise, temperature-stable voltage reference for the ADC.
(C) Switch resistors into the op-amp feedback path at set levels to alter gain.
(D) Function as a high-speed synchronous demodulator for phase-sensitive signals.

2004

253. In a 4-to-20mA loop, if the loop resistance increases (e.g., adding longer wire), the current transmitter will:
(A) Reduce its output current below the calibrated loop levels.
(B) Force higher current through the loop to overcome impedance.
(C) Execute an automatic shutdown sequence to prevent loop damage.
(D) Increase its output voltage to maintain the loop current.

2021

254. A loop-powered or 2-wire transmitter uses the 4 mA "live zero" base current to:
(A) Transmit high-frequency digital telemetry back to the receiver module.
(B) Maintain sensor temperature to prevent condensation.
(C) Power the internal transmitter electronics.
(D) Drive an integrated high-current local display relay.

2022

255. When connecting a 4-to-20mA transmitter to a voltage-input ADC, what simple component is used to convert the current back to a voltage?
(A) A high-gain instrumentation amplifier.
(B) A precision shunt resistor.
(C) A high-tolerance differentiating capacitor.
(D) A fast-switching silicon diode rectifier.

2010

256. Thermocouple cold-junction compensation assumes that the ambient temperature sensor is located:
(A) Inside the high-temperature furnace chamber being monitored.
(B) Out in the open ambient environment outside the facility.
(C) Directly on the silicon substrate of the microprocessor die.
(D) At the junction where thermocouple wires meet copper PCB traces.

2023

257. An all-electronic analog multiplexer (using CMOS switches) is generally chosen over mechanical relays when:
(A) High-speed switching (thousands of channels per second) is required.
(B) Perfect galvanic isolation is required between channels.
(C) Measuring nano-volt level signals with zero ON-resistance is necessary.
(D) The system must handle 1000V common-mode voltages.

2004

258. Flying-capacitor multiplexing is a technique used primarily to:
(A) Increase the analog multiplexing transfer speed into the high-frequency megahertz range.
(B) Serve as a high-order active low-pass filter to block high-frequency noise before the ADC.
(C) Provide high common-mode rejection by switching a charged capacitor from sensor to ADC.
(D) Capture and accumulate electrical energy to supply continuous power to remote active sensors.

2024

259. How does a piezoresistive silicon pressure transducer inherently behave?
(A) It acts as a Wheatstone bridge on a silicon diaphragm.
(B) It acts as a high-sensitivity variable capacitor

Click Here to Buy book on Flipkart

array.
(C) It acts as a single-element micro-machined resistor.
(D) It acts as an active piezoelectric charge generator.

2021
260. A standard potentiometer used to measure angular position has a "dead band" or "blind spot." This refers to:
(A) The operational frequency limit where sensor response drops to zero.
(B) The extreme threshold temperature where the resistive carbon track melts.
(C) The precise geometric point where voltage crosses zero volts.
(D) The physical break in the resistive track between rotational limits.

2023
261. High-level semiconductor transducer interfaces often output 0-5V or 0-10V directly. The signal conditioning required for these to connect to a standard ADC is typically:
(A) A highly specialized, high-gain differential instrumentation amplifier.
(B) Minimal, typically consisting of an anti-aliasing filter and a buffer.
(C) A dedicated low-noise charge amplifier for high-impedance devices.
(D) An active high-speed synchronous demodulator for phase detection.

2003
262. Strain-gauge to frequency conversion is beneficial in high-noise environments like rotating machinery shafts because:
(A) It provides a way to significantly amplify the baseline physical gauge factor of the sensor.
(B) It completely eliminates any requirement for establishing an external Wheatstone bridge.
(C) Frequency signals are immune to amplitude noise during telemetry or slip ring transmission.
(D) It inherently delivers continuous excitation power to the rotating strain gauge elements.

2018
263. When a differential pressure (DP) flow meter is used to measure liquid flow in a pipe, the pressure drop is measured across an obstruction such as:
(A) A heated thermal element.
(B) A spinning turbine rotor.
(C) A buoyant float mechanism.
(D) An inline orifice plate.

2010
264. An anemometer (thermal flow meter) measures gas flow based on:
(A) The heat transfer rate from a heated sensor to the flowing gas.
(B) The differential pressure created by gas molecules hitting a target paddle.
(C) The measured propagation speed of high-frequency sound waves through gas.
(D) The degree of physical pipe twisting caused by internal Coriolis forces.

NODIA

2011
265. In float-driven level sensing, a potentiometer is often connected to the float via a mechanical linkage. What is the primary source of error in this analog system?
(A) Low-frequency thermal drift in the baseline potentiometer track.
(B) Hysteresis, friction, and mechanical wear in the linkage.
(C) High-frequency electromagnetic interference blocking transmission.
(D) Unwanted thermoelectric Seebeck voltage offsets at the wiper.

2015
266. A precision high-resolution differential thermometer circuit would best employ which sensor type due to its extreme sensitivity over a narrow temperature span?
(A) Type S Thermocouple
(B) NTC Thermistor
(C) Platinum RTD
(D) Bimetallic strip

2023
267. Zero drift in a DC amplifier is defined as:
(A) The slow output voltage variation over time or temperature under zero input.
(B) The continuous, long-term degradation of absolute amplifier gain parameters.
(C) The peak operational frequency limit where output gain drops to absolute zero.
(D) The transient duration required for the output to return to zero after steps.

2004
268. Chopper amplifiers are specifically designed to eliminate:
(A) High-frequency electromagnetic RFI noise.
(B) Quantization noise inside the ADC converter.
(C) DC offset and low-frequency zero drift.
(D) High-frequency signal aliasing during

sampling.

2018

269. The "loading effect" of a voltmeter is most severe when measuring a circuit with:
(A) Extremely low source impedance.
(B) High frequency signal components.
(C) Extremely low output voltages.
(D) High internal source impedance.

NODIA

2017

270. An ideal operational amplifier has an infinite Common-Mode Rejection Ratio (CMRR). In a practical op-amp, a finite CMRR means that:
(A) The active amplifier becomes physically incapable of delivering output current.
(B) The operational amplifier functions strictly with single-ended input configurations.
(C) A common-mode input voltage will create an unintended output voltage change.
(D) The high-frequency closed-loop bandwidth response remains perfectly flat.

****

ANSWERS

1. (B) $Z_{\{\in\}}$ must be significantly greater than $Z_{\{out\}}$.
Maximum voltage transfer in signal conditioning circuits is achieved when the input impedance of the receiving amplifier is much larger than the output impedance of the sourcing sensor. This condition prevents loading effects by ensuring that almost the entire signal voltage drops across the amplifier input terminals rather than being lost across the internal impedance of the sensor.

2. (D) The reduction of measured voltage due to current drawn by the measuring instrument.
The loading effect in analog measurement systems refers to the systematic error where connecting a measuring instrument alters the state of the circuit being measured. When the instrument draws a non-zero current through the source impedance, it causes an internal voltage drop, which ultimately reduces the actual voltage available at the input terminals of the measurement device.

3. (A) SNR is defined as the ratio of the power of a signal to the power of background noise.
The signal-to-noise ratio serves as a fundamental metric in sensing systems to quantify signal quality. It is mathematically defined as the ratio of the desired signal power to the unwanted background noise power. A higher value indicates a cleaner signal where the target measurement is easily distinguishable from the background electrical or thermal noise.

4. (C) Voltage measurements require a low input impedance amplifier to minimize noise.
Voltage measurements require a very high input impedance, not a low one, to prevent loading the source and causing signal attenuation. High input impedance minimizes the current drawn from the sensor, ensuring precise measurement. Low input impedance is incorrect because it would draw significant current, resulting in significant loading errors and incorrect voltage readings.

5. (A) A voltage follower with an input impedance of $100\,G\Omega$.
Piezoelectric sensors possess extremely high output impedance and act as charge sources. Interfacing them with a low-input impedance amplifier causes severe signal attenuation and high-pass filtering of the signal. A voltage follower with an exceptionally high input impedance of one hundred gigohms prevents loading, preserving the weak charge signal generated by the transducer.

6. (D) Random thermal motion of charge carriers in a conductor.
Thermal noise, also known as Johnson-Nyquist noise, is an inherent thermodynamic phenomenon present in all electrical conductors. It is generated by the random thermal agitation of charge carriers, such as electrons, inside any resistive material. This noise power is directly proportional to absolute temperature, the resistance of the conductor, and the measurement system bandwidth.

7. (B) Flicker ($\frac{1}{f}$) noise

Flicker noise, commonly referred to as one-over-f noise, exhibits a power spectral density that is inversely proportional to the signal frequency. Because of this spectral distribution, it becomes the dominant noise source at very low frequencies in electronic systems. It is primarily caused by impurities and carrier trapping phenomena at semiconductor material junctions.

8. (C) Infinite and Zero
An ideal operational amplifier acts as a perfect voltage amplifier and signal buffer. To prevent drawing any current from the input source, it must have infinite input impedance. To ensure that the output voltage remains completely stable and unaffected by any connected load, its theoretical output impedance must be exactly zero ohms.

9. (D) The closed-loop gain is determined solely by the feedback resistor.
In an inverting operational amplifier configuration, the closed-loop voltage gain is determined by the ratio of the feedback resistor to the input resistor. Stating that the gain is determined solely by the feedback resistor is incorrect because the input resistor plays an

Downloaded from www.pdf.tube

equally critical role in setting both the circuit gain and the overall input impedance.

10. (A) Both A and R are true and R is the correct explanation of A.
Buffer applications for high-impedance sensors require an amplifier stage that does not load the transducer. The non-inverting operational amplifier configuration provides an exceptionally high input impedance because the input signal connects directly to the non-inverting gate terminal. This design minimizes the current drawn from the sensor, thereby preventing signal attenuation caused by loading effects.

11. (B) It creates a constant DC output error when the input is zero.
Input offset voltage represents the small differential direct current voltage required at the operational amplifier input terminals to force the output voltage to zero. In direct current signal amplification, this parameter is amplified by the closed-loop gain of the circuit, resulting in a constant, unwanted direct current offset error at the output.

12. (B) Adding a compensation resistor at the non-inverting input.
Input bias currents flowing into the operational amplifier terminals create unwanted voltage drops across the circuit resistors, leading to measurement errors. To compensate for this effect, a resistor is added to the non-inverting input. This resistor is sized to equal the parallel equivalent of the inverting terminal resistors, balancing the voltage drops at both inputs.

13. (A) One
A Wheatstone bridge circuit is classified based on the number of active sensing elements used in its four-arm topology. A quarter-bridge configuration contains exactly one variable resistive element, such as a single strain gauge, while the remaining three arms of the bridge consist of highly stable, fixed reference resistors of nominal resistance value.

14. (C) It offers maximum sensitivity and temperature compensation.
A full-bridge Wheatstone configuration utilizes active variable elements in all four arms. This arrangement yields four times the electrical sensitivity of a quarter-bridge for a given physical strain. Additionally, because thermal changes affect all matching gauges identically, temperature-induced resistance drifts naturally cancel out, providing highly accurate and temperature-compensated strain measurements.

15. (D) Zero volts
A Wheatstone bridge is balanced when the ratio of resistances in the two parallel branches is perfectly equal. Under this balanced condition, the electrical potentials at the two intermediate measurement nodes are identical. Consequently, the differential voltage difference across these nodes is theoretically zero volts, serving as an ideal null baseline for subsequent measurements.

16. (C) $V_{out} = V_{ex} \times \frac{\Delta R}{4R}$

For a quarter-bridge configuration with a single active element of nominal resistance, a small change in resistance produces a differential output voltage. The relationship is derived from the voltage divider equations of the two bridge arms. For small fractional changes in resistance, the output voltage is approximately equal to the excitation voltage multiplied by delta-R over four-R.

17. (B) It eliminates the measurement error caused by lead-wire voltage drops.
When resistive sensors are located far from the instrumentation system, the resistance of the long lead wires causes significant voltage drops under constant voltage excitation. Constant current excitation forces a regulated, known current through the sensor regardless of lead-wire resistance, effectively eliminating voltage drop errors and ensuring highly accurate remote measurements.

18. (D) It causes self-heating, which drifts gauge resistance.
Continuous constant voltage excitation of a strain gauge bridge results in a continuous flow of electric current through the resistive elements. This continuous current dissipates electrical power as heat, raising the sensor temperature. This self-heating effect alters the baseline resistance of the gauges, causing unwanted thermal drift and measurement errors over time.

19. (A) To minimize sensor self-heating and conserve power.
Pulsed-mode bridge excitation operates by applying the excitation voltage only during brief, periodic measurement intervals rather than

NODIA

continuously. This technique dramatically lowers the average electrical power dissipated within the bridge elements. Consequently, it minimizes sensor self-heating errors and significantly conserves power, making it ideal for battery-operated remote data acquisition applications.

20. (A) P-2, Q-1, R-4, S-3
Op-amp performance relies on specific parameters. Slew rate defines the maximum speed of output voltage changes. Common-mode rejection ratio represents the ability to suppress common signals. Input offset voltage is the voltage needed to force the output to zero. The gain-bandwidth product is a key high-frequency performance constant. These definitions map directly to the corresponding attributes.

21. (A) Three operational amplifiers: two buffers and a differential stage.
The classic instrumentation amplifier architecture consists of three operational amplifiers. The input stage uses two amplifiers configured as non-inverting buffers to provide exceptionally high input impedance. The second stage uses a third operational amplifier configured as a differential amplifier to precisely amplify differential signals while rejecting common-mode noise across the inputs.

22. (D) To suppress identical noise signals on both inputs.
The fundamental purpose of the common-mode rejection ratio in an instrumentation amplifier is to evaluate its ability to reject unwanted common-mode signals. In practical environments, noise often couples equally onto both signal lines. A high rejection ratio ensures that these identical noise signals are suppressed while only the differential sensor signal is amplified.

23. (B) They are exclusively used for converting current to voltage.
Instrumentation amplifiers are highly versatile differential voltage amplifiers designed to provide high input impedance and superior common-mode rejection. It is incorrect to state that they are exclusively used for converting current to voltage. Transimpedance amplifiers, rather than instrumentation amplifiers, are the specific active circuits designed primarily for current-to-voltage conversion applications.

24. (C) Using a balanced, symmetrical bridge with shielded twisted-pair cables.
Minimizing common-mode voltage at the source requires a balanced, symmetrical bridge configuration combined with shielded twisted-pair cabling. Symmetrical bridge arms ensure that ambient noise couples equally to both measurement lines, forming a common-mode signal. Shielded twisted-pair cables then provide electrostatic shielding and electromagnetic noise cancellation to further suppress interference before it reaches the amplifier.

25. (D) Optical, transformer, or capacitive coupling.
Isolation amplifiers break the galvanic path between the input and output circuits to protect sensitive equipment and eliminate ground loops. This is accomplished using non-conductive coupling barriers. The three primary physical methods employed to achieve this isolation are optical transmission, transformer magnetic coupling, or capacitive electric field coupling across the barrier.

26. (A) When measuring a low-voltage sensor with high common-mode voltage.
A high-performance floating data amplifier is essential when measuring low-voltage sensor signals that sit on top of large common-mode voltages. Without proper floating isolation, the high common-mode voltage can saturate or damage standard non-isolated measurement electronics. Floating the amplifier input stage allows the system to resolve millivolt-level differential signals safely and accurately.

27. (B) To isolate signals while enabling software-controlled variable gain.
In industrial signal conditioning, programmable-gain isolators serve a dual purpose. They provide essential galvanic isolation to protect control systems and break ground loops while allowing the system software to dynamically adjust the signal gain. This enables the acquisition system to optimize resolution and dynamic range for various sensors with different output voltage spans.

28. (B) It modulates DC to AC, amplifies it, and synchronously demodulates it to DC.
A chopper amplifier achieves exceptionally low direct current offset and drift through a modulation-demodulation process. The low-frequency or direct current input signal is

Click Here to Buy book on Amazon

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

modulated onto a high-frequency alternating current carrier, amplified by a stable alternating current amplifier, and then synchronously demodulated back to direct current. This process effectively shifts low-frequency noise outside the band.

29. (A) DC offset drift and low-frequency $\frac{1}{f}$ noise.

Auto-zeroing is a dynamic correction technique designed to minimize electronic errors in high-precision amplifiers. By periodically sampling and storing the amplifier internal offset voltage on a capacitor, the circuit continuously subtracts this error from the active signal. This process highly mitigates direct current offset drift and low-frequency one-over-f flicker noise.

30. (C) II

Chopper amplifiers are designed to eliminate direct current offset and drift, making the first statement correct. They achieve this through modulation and synchronous demodulation, confirming the third statement. The second statement is incorrect because these amplifiers specifically avoid direct DC amplification, instead converting the input into an AC signal before amplification occurs.

31. (D) Unwanted current flowing due to potential differences between ground points.

A ground loop occurs when multiple points in a system are connected to ground at different physical locations, creating multiple paths to earth. If potential differences exist between these ground points, an unwanted current flows through the ground conductors. This circulating current couples directly into signal lines, generating significant electrical noise.

32. (C) Single-point (star) grounding

For low-frequency precision measurement systems, single-point or star grounding is highly recommended. In this configuration, all subsystem ground returns are tied to a single physical point. This eliminates the circulating current loops that occur when multiple ground paths exist, preventing ground potential differences from corrupting highly sensitive, low-frequency sensor measurements.

33. (B) In high-frequency systems where cable impedance is significant.

Multi-point grounding is preferred in high-frequency systems where the parasitic inductance of ground leads makes single-point grounding ineffective. At high frequencies, long ground wires act as high-impedance inductors rather than low-resistance grounds. Connecting components to the nearest low-impedance ground plane minimizes ground path impedance and reduces high-frequency noise radiation.

34. (D) Propagation of damaging high-voltage transients.

Inadequate electrical isolation between subsystems in industrial environments allows common-mode noise and ground loops to propagate freely. More critically, without isolation barriers, high-voltage electrical transients caused by lightning or heavy inductive switching can travel directly into sensitive measurement electronics, leading to catastrophic equipment failure, severe data corruption, and safety hazards.

35. (A) Capacitively coupled electrostatic noise.

Shielded signal cables are designed with a conductive outer layer that surrounds the signal-carrying conductors. This conductive shield intercepts ambient electric fields, shunting the resulting capacitive leakage currents directly to ground. Consequently, it protects the internal signal wires from capacitively coupled electrostatic noise generated by nearby power lines or electrical equipment.

NODIA

36. (C) It drives a guard conductor around the input node to the same potential, stopping leakage.

Guard circuits are utilized in high-impedance, low-level measurements to eliminate leakage currents. The circuit operates by actively driving a shielding conductor surrounding the high-impedance input node to the exact same electrical potential as the signal node itself. Because there is zero potential difference across the insulation, leakage currents are completely prevented.

37. (A) A low-pass filter, attenuating high-frequency signal components.

Parasitic capacitance between signal conductors and the cable shield, combined with the source impedance of the sensor, forms an unintended resistor-capacitor network. This network acts as a low-pass filter. Consequently, it attenuates high-frequency signal components and limits the overall bandwidth of the measurement system, distorting fast-changing signals.

38. (D) Active guarding of the cable shield.
Active guarding of the cable shield is the most effective technique for mitigating parasitic capacitance in high-impedance sensor cables. By driving the inner shield of the cable with a low-impedance unity-gain buffer to match the signal potential, the potential difference across the cable capacitance becomes zero, eliminating capacitive charging currents and signal degradation.

39. (B) Feedback resistor and capacitor values.
In a first-order active low-pass filter using an operational amplifier, the cut-off frequency is determined by the values of the resistor and capacitor in the feedback and input network. The active op-amp primarily serves to buffer the signal and provide gain, while the physical RC time constant dictates the frequency response.

40. (C) I and III
Second-order active filters exhibit a roll-off rate of negative forty decibels per decade in the stopband, confirming the first statement. The Sallen-Key topology is a widely used configuration for implementing these filters, making the third statement correct. Statement two is incorrect because second-order designs require at least two resistors and two capacitors.

41. (D) They provide signal gain and minimize loading effects.
Active filters utilize operational amplifiers in combination with passive resistor-capacitor networks. Unlike passive filters, which can load the signal source and attenuate the signal, active filters provide high input impedance to minimize loading, low output impedance to drive subsequent stages, and the capability to supply configurable signal gain within the same stage.

42. (A) A diode-resistor network for piecewise linear approximation.
Hardware-based analog linearization circuits frequently utilize diode-resistor networks to correct non-linear sensor outputs. By arranging diodes to switch on at different voltage thresholds, the network alters the circuit gain in a step-by-step manner. This technique creates a piecewise linear approximation of the inverse non-linear curve, effectively linearizing the final analog voltage.

43. (B) To nullify the initial output so only the change is amplified.
Bridge circuits measuring parameters like strain or temperature often have a large baseline output voltage compared to the small signal variations of interest. Signal offsetting is required to subtract or nullify this initial baseline voltage. This ensures that only the relevant dynamic changes are amplified, maximizing the resolution of the measurement system.

44. (B) Polynomial curve fitting and look-up tables.
Digital linearization algorithms process raw digitized sensor values using software-based calculations to correct non-linearities. This is typically achieved using high-order polynomial curve fitting equations or pre-defined look-up tables stored in memory. These digital methods provide superior flexibility and accuracy compared to analog circuits, compensating for complex sensor curves.

45. (A) It is immune to voltage drops over long lines.
In industrial environments, transmitting signals as current rather than voltage is highly preferred. Because the current in a closed loop remains uniform throughout its entire length, the system is completely immune to voltage drops caused by the electrical resistance of long transmission lines, ensuring accurate measurements over great physical distances.

46. (C) The minimum measurement (live zero).
The four milliampere signal level in a standard current loop represents the minimum measurement value, serving as a live zero. This design choice allows the monitoring system to easily distinguish between a minimum scale reading and a loop failure. A current reading of zero milliamperes immediately signals a wire break or system fault.

47. (D) Voltage-to-Current converter
Translating a voltage signal into a proportional current signal requires a voltage-to-current converter. This electronic circuit accepts an analog input voltage, such as zero to ten volts, and controls the current flowing through a loop to range between four and twenty milliamperes, enabling noise-immune transmission over long distances in industrial environments.

Downloaded from www.pdf.tube

48. (C) To break the galvanic path, preventing ground loops.
An isolated current transmitter in a four-to-twenty milliampere loop is designed to break the direct galvanic path between the sensor and the receiver. This isolation prevents the formation of ground loops, suppresses high common-mode voltages, and protects the sensitive control-side electronics from high-voltage transients that can occur in industrial cabling.

49. (B) The Seebeck effect
Thermocouples operate on the principle of the Seebeck effect, which is a thermoelectric phenomenon. When two dissimilar electrical conductors are joined together to form a junction and exposed to a temperature gradient, an electrical potential difference is generated across the open ends. This open-circuit voltage is proportional to the temperature difference.

50. (D) I and IV
Thermocouples measure the temperature difference between the hot and cold junctions, not absolute temperature directly, making statement one incorrect. Cold-junction compensation is a universal requirement for all thermocouple types, making statement four incorrect. Statements two, three, and five are factually correct descriptions of the implementation of cold-junction compensation.

51. (A) The tip is often welded to grounded, high-voltage structures.
Thermocouples in industrial furnaces often have their measuring tips welded directly to metal structures. These structures can be electrically grounded or carry high common-mode voltages. Isolated measurement is required to prevent large ground currents from flowing through the thermocouple wires, which would damage the measurement electronics and corrupt the temperature readings.

52. (C) Frequency signals are highly immune to amplitude noise.
Converting the small analog voltage of a thermocouple into a frequency signal near the measurement point is highly advantageous for noise immunity. Frequency-modulated signals are represented by transition rates rather than voltage amplitudes, making them exceptionally robust against amplitude-based electrical noise, electromagnetic interference, and voltage drops during transmission.

53. (A) To enable compensation for lead-wire resistance.
In a three-wire resistance temperature detector configuration, the third wire is added specifically to enable compensation for lead-wire resistance. By routing this wire to a high-impedance terminal in the bridge or measurement circuit, the voltage drop across the active lead wires can be mathematically cancelled out, preserving measurement accuracy.

NODIA

54. (D) Relatively linear, with a positive temperature coefficient.
Platinum resistance temperature detectors are characterized by a highly predictable, relatively linear relationship between temperature and electrical resistance. These metallic sensors exhibit a positive temperature coefficient, meaning that their electrical resistance increases consistently as the temperature rises. This behavior makes them highly reliable for precision temperature measurements across wide ranges.

55. (B) All three lead wires must have equal resistance.
Lead-wire compensation in a three-wire RTD bridge relies on the assumption that the resistances of the lead wires are identical. When these resistances are equal, the voltage drops across the two current-carrying leads balance each other within the bridge branches, enabling precise cancellation of the lead-wire effects on the temperature measurement.

56. (C) To correct the non-linear bow in the resistance curve.
Although platinum RTDs are highly stable and relatively linear, their resistance-temperature relationship exhibits a slight non-linear curve or bow over wide operating ranges. The primary role of an RTD analog linearization circuit is to apply a corrective non-linear feedback response that straightens this bow, ensuring a highly accurate, linear output.

57. (D) A non-linear, typically negative temperature coefficient.
Thermistors are semiconductor-based temperature sensors characterized by an extremely high sensitivity to temperature changes. They typically possess a highly non-

linear relationship where electrical resistance decreases exponentially as temperature increases. This negative temperature coefficient behavior allows them to detect minute temperature fluctuations, though over a relatively narrow operating range.

58. (A) The Steinhart-Hart equation
The Steinhart-Hart equation is a highly accurate third-order polynomial model used to characterize the non-linear resistance-temperature relationship of thermistors. It relates the reciprocal of absolute temperature in Kelvin to the natural logarithm of the resistance, providing exceptional precision for calibration and digital measurement conversions over wide ranges.

59. (B) Provide a narrow, roughly linear voltage output range.
Placing a fixed resistor in series with a highly non-linear negative temperature coefficient thermistor creates a modified voltage divider. This configuration shapes the overall electrical response of the divider, providing a narrow, roughly linear voltage output range. This analog technique simplifies subsequent signal conditioning and digitizing without requiring complex mathematical corrections.

60. (A) Both A and R are true and R is the correct explanation of A.
Thermistors are highly preferred for high-resolution differential thermometers because of their exceptional sensitivity to temperature changes. Their exponential resistance change per degree Celsius is significantly larger than the linear changes observed in RTDs or the small thermoelectric voltages of thermocouples. This large sensitivity minimizes noise limitations, enabling high-resolution measurements of small temperature differences.

61. (A) Transmit data robustly over an optical isolator.
Converting a thermistor resistance change into a variable frequency signal is highly useful for transmitting data robustly across an optical isolator. Frequency signals are immune to the non-linearities and gain drifts of optical isolation components, allowing highly accurate, galvanically isolated temperature readings to be transmitted to digital control systems.

62. (C) The forward voltage drop of a PN junction.
Semiconductor temperature sensors exploit the highly predictable, linear temperature dependence of a silicon PN junction forward voltage drop when biased with a constant current. This forward voltage decreases linearly with temperature, providing an easily measurable electrical signal that is highly consistent and suitable for integration into solid-state electronic measurement circuits.

63. (A) -2 mV / °C
A standard silicon PN junction diode biased with a constant forward current exhibits a highly predictable temperature coefficient of approximately negative two millivolts per degree Celsius. This negative temperature coefficient means that as the temperature rises, the forward voltage drop across the PN junction decreases linearly by this specific amount.

64. (C) It outputs a current that is directly proportional to absolute temperature in Kelvin.
Absolute temperature-to-current converters, such as the AD590 integrated circuit, are designed to generate an output current that is directly proportional to absolute temperature in Kelvin. This configuration produces a highly predictable output, typically one microampere per Kelvin, which is highly robust against voltage drops and transmission line noise.

65. (B) In the loop determining charging current.
In temperature-to-frequency conversion circuits utilizing diodes, the sensor diode is placed in the feedback loop that determines the charging current of an integrating capacitor. Because the diode forward voltage varies linearly with temperature, the charging current and subsequent relaxation oscillation frequency vary proportionally, converting temperature changes directly into frequency.

66. (D) To sequentially route multiple analog inputs to one device.
In data acquisition systems, a multiplexer acts as an electronically controlled multi-position switch. Its primary function is to sequentially route multiple analog input signals from various sensors to a single shared analog-to-digital converter or signal conditioning block. This approach significantly reduces system cost, complexity, and physical space requirements.

Click Here to Buy book on Flipkart

67. (A) Cross-talk from shared grounds on different electrical potentials.
Isolated multiplexing is critical when measuring multiple thermocouples to prevent electrical cross-talk caused by shared grounds at different potentials. Thermocouple junctions are frequently in direct contact with grounded industrial structures that can differ by hundreds of volts. Isolation prevents damaging ground loop currents from flowing between the multiplexed channels.

68. (C) ON-resistance and leakage currents.
All-electronic multiplexers utilizing solid-state semiconductor switches offer exceptionally fast switching speeds and high durability compared to mechanical relays. However, they suffer from inherent limitations, specifically non-zero ON-resistance and small off-state leakage currents. These parasitic characteristics can introduce voltage drops and cross-channel errors in highly sensitive, high-impedance measurement circuits.

69. (A) Grounding unused channels and lowering source impedance.
Cross-talk between channels in analog multiplexers occurs due to parasitic capacitive and inductive coupling. This interference can be significantly reduced by grounding unused input channels, which shunts stray signals to earth. Additionally, lowering the source impedance of the connected sensors helps prevent electrostatic noise from developing measurable voltages on the lines.

70. (B) P-2, Q-4, R-3, S-1
Each sensor type exhibits unique properties. Thermocouples generate voltage from thermal gradients via the Seebeck effect. Resistance temperature detectors display a linear positive resistance change. Thermistors feature a highly non-linear negative resistance change. PN junction diodes provide a linear negative two millivolt per degree Celsius voltage response. These matchings represent basic physical behavior.

71. (B) A Wheatstone bridge
Strain gauges experience extremely small resistance changes, typically in the milliohm range, when subjected to micro-strain. To accurately detect and measure these minute variations, signal conditioning circuits primarily utilize a Wheatstone bridge configuration. The bridge converts the tiny fractional change in resistance into a highly measurable differential voltage signal.

72. (C) The timing resistor in the RC network.
In potentiometer-to-frequency conversion circuits used for position or pressure sensing, the variable resistance of the potentiometer is utilized as the timing resistor in an RC oscillator network. As physical displacement alters the potentiometer resistance, it directly changes the RC charge-discharge time constant, modulating the output frequency proportionally.

73. (D) Include integrated signal conditioning for high-level outputs.
High-level semiconductor pressure transducers differ from basic strain gauges because they feature integrated, on-chip signal conditioning electronics. While basic gauges output low-level millivolt signals, these integrated transducers contain excitation sources, instrumentation amplifiers, temperature compensation circuitry, and high-level voltage or current output buffers directly within the single sensor package.

74. (A) prevents sparks from electrical faults in hazardous areas.
Isolated pressure control systems are crucial in explosive or hazardous environments to ensure intrinsic safety. Isolation barriers limit the electrical energy entering the hazardous zone, preventing any sparks or thermal faults in the control equipment from igniting volatile gases or dust, ensuring safe operation under fault conditions.

75. (B) a changing resistance
Spring-driven rheostat circuits used in force measurement operate by linking physical force to mechanical displacement. As the applied force displaces a spring-loaded wiper along a resistive track, it directly alters the active length of the conductor. This physical mechanism translates the mechanical input into a changing electrical resistance.

76. (B) Precision excitation, an instrumentation amplifier, and a low-pass filter.
Interfacing a high-resolution load cell platform requires a specific combination of signal conditioning blocks to resolve the small, noise-prone millivolt signals. The setup must include highly stable precision excitation to power the

Downloaded from www.pdf.tube

internal bridge, a low-drift instrumentation amplifier to amplify the differential signal, and a low-pass filter to remove ambient high-frequency noise.

77. (B) The signal must be transmitted over long distances in noisy environments with high noise immunity.
Converting a strain-gauge bridge output directly to a frequency signal is highly advantageous when transmitting measurements over long distances in electrically noisy environments. Because frequency-modulated signals are characterized by timing transitions rather than voltage levels, they are immune to amplitude attenuation and noise, ensuring reliable data transmission without signal degradation.

78. (C) Bernoulli's principle, relating pressure drop to flow rate squared.
Differential pressure flow meters determine fluid velocity based on Bernoulli's principle. When fluid passes through a restriction in the pipe, such as an orifice plate, its velocity increases, causing a localized drop in static pressure. This physical pressure drop is directly proportional to the square of the fluid flow rate.

79. (D) Square root extraction
In differential pressure flow measurement, the physical relationship dictates that the measured pressure drop is proportional to the square of the fluid flow rate. To obtain a linear output signal directly proportional to the actual flow rate, the conditioning circuit must perform a mathematical square root extraction on the raw pressure signal.

80. (C) I and III
In turbine flowmeters, the rotational speed of the rotor is directly proportional to fluid velocity, yielding a proportional output frequency, validating statement one. The rotor rotation is typically detected contactlessly using a magnetic pickup, confirming statement three. Statement two is incorrect because these meters are inherently linear and do not require square root extraction.

81. (B) A rotary potentiometer or encoder.
A hinged vane flow meter operates by placing a movable vane directly in the fluid stream. The flowing fluid exerts a force on the vane, causing it to deflect by an angle proportional to the velocity. This rotational deflection is converted into an electrical signal using a rotary potentiometer or an optical encoder.

82. (D) Measures power needed to maintain a constant temperature difference.
Thermal anemometers measure fluid flow by exploiting the cooling effect of fluid passing over a heated sensor. The signal conditioning circuit operates by continuously measuring the electrical power required to maintain a constant temperature difference between the heated element and the ambient fluid, providing a highly sensitive measurement of mass flow rate.

83. (A) The position of the float.
In float-driven level measurement systems, a buoyant float rises and falls in accordance with the liquid level in a tank. This mechanical movement is coupled directly to the wiper of a rotary or linear potentiometer. Consequently, the resulting electrical output voltage is directly proportional to the physical position of the float.

84. (C) Refractive index differences, altering total internal reflection.
Optical level sensors detect the presence of liquid by utilizing refractive index differences between air and liquid. When the sensor tip is in air, light from an internal LED experiences total internal reflection and is directed to a photodetector. When submerged, the liquid alters refraction, causing light to escape and signaling submersion.

NODIA

85. (A) The change in heat dissipation when submerged in liquid versus air.
Thermal level sensing circuits operate by detecting differences in heat dissipation rates between fluids. A heated thermistor or RTD dissipates heat much more rapidly when submerged in a liquid than when surrounded by air or gas. The signal conditioning circuit senses the resulting temperature change, indicating whether the sensor is submerged.

86. (D) A Voltage-to-Frequency Converter (VFC).
Universal advanced transducer-to-frequency conversion is implemented using a voltage-to-frequency converter. This active electronic building block accepts an analog input voltage from a sensor conditioning circuit and generates a highly stable periodic output signal whose frequency is directly proportional to the input,

enabling digital integration and high-noise-immunity transmission.

87. (B) A simple digital counter can act as the converter.
Directly converting analog sensor signals into frequency outputs provides significant system advantages. It simplifies the digital interface because a simple hardware digital counter or timer on a microcontroller can act as the analog-to-digital converter. This eliminates the need for precision analog-to-digital converters, while providing excellent noise immunity and resolution control.

88. (C) Using an AC bridge or an oscillator circuit.
Variable capacitance sensors do not pass steady-state direct current, making standard direct current bridge circuits ineffective. To measure capacitive variations, signal conditioning circuits must utilize either alternating current bridges or active oscillator circuits. In these configurations, the sensor capacitance directly modulates an alternating current signal amplitude, phase, or frequency for measurement.

89. (D) Infinite output impedance
An ideal current source must provide a completely constant excitation current to an RTD regardless of changes in the sensor resistance or lead-wire impedance. To achieve this performance, the current source must possess an infinitely high output impedance, ensuring that load variations do not affect the regulated current level.

90. (A) II and IV
Guarding circuits are designed to eliminate leakage currents, making the first and third statements correct. The second statement is incorrect because guarding involves driving a shield to the same active potential as the signal node, not ground. The fourth statement is incorrect because guard rings protect high-impedance nodes, not low-impedance nodes.

91. (B) The system CMRR
In a differential amplifier configuration, the ability to reject common-mode noise depends on the precise matching of the resistor networks. Even a microscopic mismatch in resistor values imbalances the gain between the inverting and non-inverting paths. This imbalance directly degrades the common-mode rejection ratio, allowing common noise to be amplified.

92. (B) Modulating the input to a high frequency, amplifying, and demodulating it.
Chopper-stabilized amplifiers mitigate low-frequency one-over-f flicker noise by modulating the low-frequency input signal to a high-frequency carrier prior to amplification. The amplified signal is subsequently demodulated back to direct current. This modulation-demodulation process effectively shifts the signal away from the low-frequency region where flicker noise is concentrated, preserving signal integrity.

93. (A) A precision rectifier and low-pass filter
Variable reluctance sensors generate an alternating current output voltage whose amplitude and frequency depend on the target speed. To convert this alternating current signal into a stable direct current voltage, the signal conditioning circuit utilizes a precision rectifier followed by a low-pass filter to smooth out high-frequency ripples.

94. (C) It protects ADC electronics and breaks ground loops.
Placing an isolation amplifier in a data acquisition system measuring high-voltage batteries provides critical safety and performance functions. It breaks the galvanic path between the high-voltage battery stack and the low-voltage control circuitry, preventing dangerous ground loops and protecting sensitive analog-to-digital converter electronics from high-voltage transients.

95. (D) A second-order active filter with an op-amp.
The Sallen-Key configuration is a widely implemented topology used to construct active second-order filters. It incorporates a single operational amplifier configured as a voltage follower or non-inverting amplifier, along with two resistors and two capacitors, to achieve a roll-off rate of negative forty decibels per decade in the stopband.

96. (C) Each pole adds 20 dB/decade (6 dB/octave) to the stopband roll-off rate.
The number of poles in an analog filter directly dictates the steepness of its frequency transition. Each additional pole introduces a phase shift and adds twenty decibels per decade, which is equivalent to six decibels per octave, to the overall roll-off rate in the stopband, allowing sharper attenuation of noise.

Click Here to Buy book on Amazon

97. (B) By adjusting a nulling potentiometer in one bridge arm.
Bridge-based offsetting circuits are designed to nullify the baseline output voltage of a sensor before amplification. This adjustment is typically achieved by placing a high-precision nulling potentiometer in one of the bridge arms. Tuning this potentiometer alters the branch resistance ratio until the differential output voltage is zeroed at the baseline.

98. (D) They are susceptible to wire voltage drops and EMI.
Zero-to-ten volt analog signals are less preferred in harsh industrial environments compared to current loops because voltage signals are highly susceptible to voltage drops along long cables. Additionally, high-impedance voltage inputs are highly sensitive to capacitively coupled electromagnetic interference, which can easily corrupt the integrity of the measured signal.

99. (A) Cold-Junction Compensation (CJC)
Thermocouples measure relative temperature by generating a voltage proportional to the difference between two junctions. To obtain an absolute reading, cold-junction compensation is fundamentally required to measure and add the reference junction voltage. RTD sensors measure absolute electrical resistance directly and therefore do not require any cold-junction compensation.

100. (C) I, IV and V
Semiconductor temperature sensors display a highly linear output, making statement one correct. They require constant excitation current, and a forward-biased silicon diode is a classic example, validating statements four and five. Statements two and three are incorrect because the Steinhart-Hart equation applies to thermistors, and silicon cannot withstand extreme temperatures.

101. (A) The local atmospheric pressure
Gauge pressure is a measure of pressure relative to the surrounding environment. To measure gauge pressure, a transducer must reference one side of its sensing diaphragm to the local atmospheric pressure. This design ensures that any changes in atmospheric pressure are cancelled out, measuring only the pressure exerted by the system.

102. (D) The ratio of full-scale output to excitation voltage.
The sensitivity of a load cell is a standardized parameter that defines the magnitude of the electrical output signal relative to the excitation voltage at maximum rated capacity. It is typically expressed in units of millivolts per volt, representing the ratio of full-scale output voltage to the applied excitation voltage.

103. (B) Low-drift Instrumentation Amplifiers
Load cells output extremely small differential voltages, often in the milliohm range, which are highly susceptible to noise and thermal drift. Conditioning these signals requires high-performance, low-drift instrumentation amplifiers. These specialized amplifiers provide the exceptionally high input impedance, low input offset drift, and superior common-mode rejection necessary to process weak signals.

104. (C) Optocouplers
In isolated multiplexed data acquisition systems, optocouplers provide the necessary galvanic barrier for digital control signals. They transmit control signals across an isolation gap using light waves, ensuring complete electrical separation between the high-voltage analog frontend and the low-voltage digital microcontroller, preventing ground loops and protecting sensitive system electronics.

105. (D) The 4-to-20mA current loop itself
A loop-powered current transmitter is designed to operate without any external power source at the sensor site. Instead, it draws its operating electrical power directly from the active four-to-twenty milliampere current loop itself. This is achieved because the minimum current in the loop is four milliamperes, which is sufficient to power the internal electronics.

NODIA

106. (A) Attenuation and DC level shift
When a sensor outputs a broad voltage range, such as negative five to positive five volts, and the receiving analog-to-digital converter accepts a narrower range, such as zero to three point three volts, scaling is required. The conditioning circuit must perform attenuation to compress the voltage span, followed by a positive DC level shift.

107. (D) $f_c = \dfrac{1}{2\pi RC}$

The cut-off frequency of a first-order passive resistor-capacitor low-pass filter represents the frequency boundary where output power drops to half of its input level. It is mathematically calculated by taking the reciprocal of two pi multiplied by the product of the resistance and the capacitance, reflecting the physical RC time constant.

108. (B) Unknown connecting lead-wire resistances adding to the measurement.
In a two-wire resistance temperature detector configuration, the resistance of the connecting lead wires is directly in series with the temperature-sensing RTD element. Because the measurement system cannot distinguish between lead resistance and sensor resistance, these unknown lead resistances add directly to the measurement, causing a significant, positive temperature measurement error.

109. (A) Common-mode noise and ground loops.
Optical isolation is highly effective at preventing common-mode noise and ground loop currents. By transmitting signals across a non-conductive physical barrier using light, it breaks the galvanic path between different subsystems. This prevents potential differences between separate ground nodes from causing noise currents to flow through sensitive measurement lines.

110. (A) Both A and R are true and R is the correct explanation of A.
Current loop transmission is highly immune to electromagnetic interference because noise primarily couples into signal wires as voltage. Because the loop receiver has low input impedance and the transmitter has high output impedance, induced voltage noise does not affect the regulated loop current, which is determined solely by the transmitter, ensuring superior signal integrity.

111. (D) Butterworth filter
The Butterworth filter response is specifically designed to provide a mathematically flat amplitude response in the passband. This response is characterized by a lack of passband ripple, meaning that signal frequencies within the passband are transmitted with uniform gain before experiencing a smooth roll-off, making it ideal for standard signal conditioning applications.

112. (C) They exhibit a linear phase response, minimizing distortion.
Bessel filters are highly preferred for conditioning time-domain signals because they exhibit a linear phase response, which corresponds to a constant group delay across the passband. This ensures that all frequency components are delayed by the exact same amount, preserving the wave shape of transient signals and preventing overshoot or distortion.

113. (B) Dynamically adjust amplifier gain to match input levels, maximizing ADC resolution.
A programmable-gain amplifier allows a data acquisition system to dynamically adjust its internal voltage amplification factor via digital control signals. This flexibility enables the system to match the sensor output span with the input range of the analog-to-digital converter, maximizing overall measurement resolution and dynamic range for various sensor outputs.

114. (D) To extract the DC signal by smoothing high-frequency ripples.
In a chopper-stabilized amplifier, the output stage low-pass filter is crucial for extracting the direct current signal. Because the modulation-demodulation process introduces high-frequency switching noise and ripples, the low-pass filter is used to smooth out these high-frequency components, leaving only the amplified, clean direct current signal at the output.

115. (A) Minimize shield-capacitive and twist-magnetic noise.
Shielded twisted pair cabling is widely utilized in signal transmission to protect weak signals from environmental noise. The twisting of the signal conductors ensures that magnetic fields induce equal and opposite voltages that cancel out, while the conductive outer shield intercepts and shunts capacitively coupled electrostatic noise directly to ground.

116. (C) Common impedance coupling causing signal interference.
When single-point grounding is implemented incorrectly, such as by daisy-chaining multiple ground connections in series, it creates common impedance coupling. The current from one subsystem flowing through the shared ground wire develops a voltage drop across its finite resistance. This voltage drop acts as an unwanted

Downloaded from www.pdf.tube

noise source in other subsystems, causing signal interference.

117. (A) Voltage gain of 1, high input impedance, and low output impedance
An operational amplifier configured as a voltage follower, or unity-gain buffer, provides a voltage gain of exactly one. It features an exceptionally high input impedance to prevent loading the signal source, and a very low output impedance to drive subsequent loads, ensuring stable voltage transfer without signal attenuation.

118. (D) Adding a voltage equivalent to cold-junction ambient temperature to the reading.
Cold-junction compensation is critical because a thermocouple measures only the temperature difference between its hot measuring junction and the cold reference junction. To find the absolute temperature, the ambient temperature at the reference terminal is measured, and a voltage equivalent to this ambient temperature is mathematically added to the thermocouple reading.

119. (B) A decrease in resistance as temperature increases.
Thermistors with a negative temperature coefficient are semiconductor devices whose electrical properties change dramatically with temperature. The identifying characteristic of an NTC thermistor is that its electrical resistance decreases exponentially as the temperature increases, allowing for highly sensitive, narrow-range temperature measurements.

120. (A) P-2, Q-3, R-4, S-1
Bridge output states depend on active elements. A balanced bridge yields a zero voltage output. A quarter-bridge with one variable element produces a slightly non-linear response. A half-bridge with opposite varying arms doubles output sensitivity. A full-bridge with four varying arms maximizes sensitivity linearly. These characteristics define resistive bridge sensor configurations.

121. (D) $20\log_{10}\left(\frac{A_d}{A_{cm}}\right)$
The common-mode rejection ratio of an operational amplifier measures its ability to amplify differential signals while suppressing common-mode noise. It is mathematically defined as twenty times the common logarithm of the ratio of the differential gain to the common-mode gain, providing a standardized logarithmic metric of amplifier performance.

122. (A) Two non-inverting buffers/amplifiers
In a classic three-operational-amplifier instrumentation amplifier, the first stage is composed of two operational amplifiers configured as non-inverting buffers. This specific design ensures that both differential input terminals exhibit an exceptionally high input impedance, preventing loading of the connected sensor while providing initial differential gain.

123. (B) Significantly greater than source Thevenin equivalent resistance.
When measuring voltage, the loading effect is minimized by ensuring that the input impedance of the measuring instrument is significantly larger than the Thevenin equivalent source resistance. This high impedance prevents current from flowing through the source resistance, thereby preventing any internal voltage drop and ensuring accurate voltage measurements.

124. (B) Transmitting digital data using an isolated ADC before the optocoupler.
Optocouplers possess highly non-linear current transfer characteristics, which makes direct analog transmission across them inaccurate. To overcome this limitation, precision systems digitize the analog sensor signal using an analog-to-digital converter before the isolation barrier. The digital data is then transmitted through the optocoupler, completely avoiding analog non-linearities.

NODIA

125. (A) Sigma-Delta ($\Sigma - \Delta$) ADC
Sigma-Delta analog-to-digital converters are highly preferred for interfacing low-level, low-frequency sensors like thermocouples and load cells. This architecture utilizes oversampling and noise shaping to achieve exceptionally high resolution, typically twenty-four bits, while its integrated digital filters inherently suppress high-frequency noise and mains interference.

126. (C) Modulating the signal onto a high-frequency carrier.
Transformers are electromagnetic devices that cannot pass constant direct current or very low frequency signals directly due to Faraday's law of induction. To transmit these signals across a transformer isolation barrier, the input signal is modulated onto a high-frequency carrier, passed

through the transformer, and then demodulated back to direct current.

127. (D) Pulsed-mode excitation
Pulsed-mode excitation is a specialized bridge biasing technique where the excitation voltage is applied in rapid, periodic pulses rather than continuously. The measurement is sampled quickly during the active pulse interval, and the excitation is immediately disabled. This highly reduces average current, minimizing power consumption and self-heating.

128. (C) It significantly reduces average power consumption and sensor self-heating.
In battery-powered IoT sensor nodes, pulsed-mode bridge excitation offers a critical advantage by dramatically reducing the average electrical power consumption of the sensor. By keeping the excitation turned off between measurement samples, the system also minimizes sensor self-heating, which prevents thermal drift and preserves measurement accuracy.

129. (B) It experiences amplitude attenuation and phase shift.
When a long signal cable acts as a low-pass filter due to parasitic capacitance, high-frequency signal components are significantly affected. Fast-changing sensor signals experience both amplitude attenuation and phase shift. This filtering effect slows down transition edges and distorts the wave shape, resulting in measurement errors.

130. (D) III
Current loops are highly immune to voltage drops, making statement one incorrect. The four-to-twenty milliampere standard is widely used in modern industry, making statement two incorrect. Statement three is correct because loop-powered transmitters are designed to draw their operating power directly from the minimum four-milliampere current loop.

131. (D) Quadruples
According to Bernoulli's principle, the differential pressure drop across a restriction in a flow meter is proportional to the square of the fluid flow rate. Consequently, if the flow rate doubles, the measured differential pressure increases by the square of two, which means it quadruples.

132. (C) a broken wire
The four milliampere live zero in a standard current loop serves as a critical safety feature. It allows the monitoring system to distinguish between a minimum measurement and a loop failure. If a wire breaks or a connection is lost, the loop current falls to zero milliamperes, indicating a broken wire.

133. (A) A feedback loop with a multiplier or diode network.
Hardware-based analog linearization circuits for RTD sensors are designed to correct the slight curvature in the resistance-temperature relationship. This is typically achieved by placing a multiplier or diode network in the feedback loop of an operational amplifier, which dynamically adjusts the circuit gain to linearize the output.

134. (D) A digital counter/timer input
A frequency-output flowmeter, such as a turbine flowmeter, generates a series of pulses whose frequency is proportional to the flow rate. This signal interfaces best with a digital counter or timer input of a microcontroller. This direct digital interface avoids the need for analog-to-digital converters, ensuring highly precise and robust flow measurements.

135. (A) Measuring the transit time of a high-frequency sound wave reflected off the liquid surface.
Ultrasonic level sensors operate by emitting a burst of high-frequency acoustic waves towards the surface of a liquid. The sensor measures the precise transit time required for the acoustic wave to travel to the surface and reflect back. Because the speed of sound is constant, this time interval is used to calculate level.

136. (A) It converts the electrical charge into a voltage while eliminating cable capacitance effects.
Piezoelectric sensors produce an electrical charge proportional to applied physical acceleration or force. A charge amplifier utilizes a feedback capacitor to integrate this charge, effectively translating it into a usable output voltage. Because the feedback loop maintains the input node at virtual ground, cable capacitance is eliminated from the gain calculation, preventing signal loss.

Click Here to Buy book on Flipkart

137. (B) Electromagnetic interference from nearby power lines
Standard alternating current power transmission lines operate at fifty or sixty hertz and generate strong surrounding alternating electromagnetic fields. When sensitive signal cables are routed in close proximity to these electrical conduits, they experience electromagnetic interference. This unwanted coupling injects low-frequency noise directly into the signal path, necessitating shielding and differential measurement techniques.

138. (B) Magnetic (inductive) coupling
Magnetic coupling occurs when changing external magnetic fields induce noise voltages within signal loops. By twisting the individual conductors of a wire pair together, the physical area of the loop is minimized, and the direction of the induced current alternates in successive twists. This geometric arrangement causes the induced noise voltages to cancel each other out.

139. (A) The periodic measurement and subtraction of internal offset voltage to minimize drift.
Real operational amplifiers suffer from internal offset voltages that drift with temperature and time. Auto-zeroing technology utilizes internal switches to periodically disconnect the inputs, measure the current offset voltage, and store it on internal capacitors. This stored offset is then subtracted from the active signal path, maintaining exceptional precision and long-term stability.

140. (A) I and III
A standard instrumentation amplifier utilizes a three-op-amp topology to achieve high performance rather than a single operational amplifier design. Furthermore, this device must maintain extremely high input impedance on both terminals to prevent loading effects on delicate sensors. Statements indicating a single op-amp construction or low input impedance characteristics are completely incorrect.

141. (D) Electrical resistance
Strain gauges function on the piezoresistive effect, where physical deformation directly alters electrical properties. When an external force causes mechanical tension or compression, the physical length and cross-sectional area of the thin metallic foil change. This structural alteration causes a proportional shift in the overall electrical resistance, which is subsequently measured using bridge circuits.

142. (C) The fractional change in electrical resistance to the applied physical strain.
The gauge factor is a fundamental dimensionless parameter that defines the sensitivity of a strain gauge. It represents the ratio of the fractional change in electrical resistance to the mechanical strain along the active axis. A higher gauge factor indicates that a smaller physical deformation will produce a larger, more measurable change in electrical resistance.

NODIA

143. (B) Temperature variations change gauge resistance and base dimensions, creating apparent strain.
Temperature fluctuations cause thermal expansion or contraction of both the test specimen and the sensor grid material itself. Additionally, the resistivity of the gauge material varies with temperature, producing a change in resistance unrelated to mechanical load. This combined thermal effect generates an apparent strain that introduces severe errors if not properly compensated.

144. (D) By placing an unstrained dummy gauge under identical thermal conditions in an adjacent bridge arm.
Temperature compensation is achieved by incorporating an unstrained dummy gauge into the adjacent arm of a Wheatstone bridge. This dummy gauge is mounted on the same material and experiences identical thermal conditions as the active gauge. Because both arms undergo equal resistance shifts due to temperature, the differential bridge output remains unaffected by thermal variations.

145. (A) Voltage divider
A potentiometer consists of a resistive element with a sliding contact known as a wiper. When a constant reference voltage is applied across the outer terminals, the position of the wiper determines the fractional resistance on either side. This configuration acts as a variable voltage divider, producing an output voltage directly proportional to mechanical position.

146. (C) Infinite input impedance
An ideal operational amplifier features infinite input impedance at both its inverting and non-inverting terminals. Because impedance

is mathematically defined as voltage divided by current, an infinite impedance prevents any current from flowing into the input terminals from the source. This characteristic ensures that the amplifier does not load the preceding signal circuitry.

147. (A) Extremely low resistance values
Measuring low resistance values with standard two-wire systems introduces significant errors because lead-wire and contact resistances are added directly to the measurement. A four-wire Kelvin configuration separates the current excitation path from the voltage sensing path. This arrangement ensures that virtually no current flows through the sensing leads, eliminating voltage drops across those lead wires.

148. (D) By separating the current-carrying wires from the voltage-sensing wires across the resistor.
The Kelvin technique utilizes two dedicated wires to deliver a constant test current through the target resistor and two separate wires to measure the resulting voltage drop. Because the high-impedance voltmeter draws virtually no current through the sensing leads, no voltage drop occurs across them. Consequently, only the voltage directly across the resistor is measured.

149. (B) Voltage-to-Frequency Converter (VFC)
Thermocouples generate a low-level analog voltage proportional to the temperature difference between their junctions. To convert this analog voltage into a digital-friendly format for long-distance transmission, a voltage-to-frequency converter is utilized. This device produces a continuous pulse train whose frequency is directly proportional to the input voltage, offering excellent noise immunity over long cables.

150. (A) I, II and IV
Signal-to-noise ratio represents the fundamental ratio of desired signal power to unwanted background noise power, typically expressed logarithmically in decibels. A higher ratio indicates a cleaner signal that is less corrupted by noise, which is highly desirable. Implementing proper grounding and shielding practices directly minimizes external noise injection, thereby improving the overall ratio in instrumentation systems.

NODIA

151. (D) An isolation amplifier
Isolation amplifiers are specifically designed to transmit analog signals across a galvanic barrier using optical, magnetic, or capacitive coupling. This device prevents direct electrical conduction, protecting sensitive low-voltage data acquisition systems from high-voltage transients on industrial sensor lines. It breaks the ground path entirely, eliminating common-mode voltage differences between separate subsystems.

152. (A) Increased susceptibility to ground loops and noise.
In a grounded thermocouple, the measuring junction is in direct electrical contact with the protective metal sheath. While this physical connection provides rapid thermal response times, it also creates an electrical path to the surrounding structure. If the structure is at a different potential than the measurement system, significant ground loops and electrical noise occur.

153. (B) Convert the signal to a 4-20mA current loop.
Voltage signals transmitted over long distances are highly susceptible to voltage drops from wire resistance and electrostatic noise. Converting the signal to a four-to-twenty milliamp current loop ensures that the current remains constant throughout the entire loop regardless of wire length. This technique provides exceptional noise immunity and preserves signal integrity in industrial environments.

154. (B) To intercept surface leakage currents by driving a surrounding trace to the node's potential.
High-impedance amplifier circuits are highly sensitive to microscopic parasitic leakage currents flowing across the printed circuit board surface. Guard rings are conductive traces that completely surround the sensitive input nodes. These rings are actively driven to the same potential as the input, reducing the voltage gradient to zero and intercepting any stray leakage currents.

155. (A) The current remains stable, reducing voltage drop errors caused by long lead wires.
Resistance temperature detectors are passive sensors requiring electrical excitation to produce a measurable voltage. When excited by a constant current source, the current flowing through the sensor remains completely stable despite changes in lead-wire resistance. The

voltage drop across the sensor can then be measured directly, eliminating errors associated with long transmission lines.

156. (C) A capacitor
An operational amplifier integrating circuit utilizes a capacitor in its feedback loop. When an input voltage is applied through an input resistor, the amplifier forces a proportional current to flow into the feedback path. Because the capacitor accumulates this current over time, the resulting output voltage becomes proportional to the time integral of the input voltage.

157. (D) A capacitor
A differentiating operational amplifier circuit places a capacitor directly at its input node, with a resistor in the feedback path. The current through the input capacitor is proportional to the rate of change of the input voltage. Since this current flows through the feedback resistor, the output voltage is proportional to the mathematical derivative of the input.

158. (C) Linearization
Many physical sensors exhibit non-linear output characteristics relative to the physical variables they measure. Linearization is the process of modifying these signals, either through specialized analog hardware circuits or digital software algorithms, to establish a directly proportional relationship. This process ensures that equal increments in the measured variable produce equal changes in the final output.

159. (B) On the isothermal terminal block transitioning to copper traces.
Cold-junction compensation requires precise knowledge of the temperature where the thermocouple alloys transition to the copper traces of the measurement system. To achieve this, a temperature sensor must be placed directly on the isothermal terminal block where this physical junction occurs. This ensures accurate tracking of the reference junction temperature for correct software mathematical compensation.

160. (A) Both A and R are true and R is the correct explanation of A.
Historically, complex analog circuits were designed to linearize non-linear sensor responses in hardware. Modern advancements in high-resolution analog-to-digital converters and low-cost microcontrollers have made digital linearization far more practical. Software lookup tables and mathematical polynomial calculations provide superior accuracy, flexibility, and ease of adjustment, directly leading to the obsolescence of hardware-based linearization methods.

161. (A) Common-mode noise present equally on both inputs.
Instrumentation amplifiers are designed with a high common-mode rejection ratio to distinguish between desired differential signals and unwanted noise. Noise from sources like power lines typically couples equally onto both signal conductors, appearing as a common-mode voltage. The amplifier actively rejects this identical common-mode noise while highly amplifying the differential voltage present between the inputs.

162. (C) Thermal resistance changes in the active gauge.
Temperature variations cause the electrical resistance of active strain gauges to change independently of any applied mechanical load, producing apparent strain. Placing an identical, unstrained dummy gauge in the adjacent arm of the Wheatstone bridge ensures both experience the same temperature. The bridge circuit naturally cancels out these equal resistance changes, isolating the mechanical strain.

163. (A) Block frequencies above half the sampling rate to prevent aliasing.
When sampling an analog signal, any frequency components higher than half the sampling frequency will fold back into the lower frequency spectrum, causing irreversible distortion. An anti-aliasing filter is positioned before the converter to block these high frequencies. This attenuation ensures that the digitized representation remains completely free from aliasing artifacts and high-frequency noise.

164. (D) Low-pass filter
An anti-aliasing filter is fundamentally structured as a low-pass filter. Its primary function is to permit low-frequency signal components to pass through to the analog-to-digital converter while aggressively attenuating all high-frequency noise and signals above the Nyquist limit. This low-pass characteristic is essential for preventing high-frequency folding in digitized data.

Downloaded from www.pdf.tube

165. (B) Attenuate AC power line noise while passing surrounding frequencies.
Power line interference at fifty or sixty hertz is a pervasive source of noise in electronic instrumentation. A notch filter, which is a highly selective band-reject filter, is designed to provide extreme attenuation over an extremely narrow frequency band centered around the power line frequency. It effectively eliminates AC hum while leaving other signal frequencies unaffected.

166. (C) A liquid point-level detector
Point-level detection requires identifying when liquid reaches a specific height in a tank. Optical level sensors utilize an infrared light source and a receiver housed within a prism. This design relies on the change in light refraction that occurs when liquid contacts the prism surface, making it ideal for point-level detection rather than continuous level tracking.

167. (D) It offers an exceptionally stable resistance-temperature relationship.
Platinum is the preferred material for precision resistance temperature detectors due to its highly stable, predictable, and linear resistance-temperature relationship. It offers excellent resistance to contamination and corrosion, ensuring long-term repeatability over a wide temperature range. These characteristics make it the global standard for high-accuracy industrial and laboratory temperature measurements.

168. (A) Cold-Junction Compensation (CJC)
Thermocouples generate a voltage that depends on the temperature difference between the measuring junction and the reference junction. If the reference junction is not held at zero degrees Celsius, its temperature must be measured independently. Cold-junction compensation is then applied to mathematically adjust the measured voltage, yielding the correct temperature at the measuring probe.

169. (B) The junction where thermocouple alloys connect to copper system traces.
In a thermocouple measurement circuit, the cold junction is the physical connection point where the specialized thermocouple alloys meet the copper conductors of the measurement instrument. This connection acts as a secondary thermocouple junction that generates an opposing voltage. Accurately measuring the temperature at this connection point is required to perform cold-junction compensation.

170. (A) P-2, Q-3, R-1, S-4
Differential pressure flow meters operate by measuring the pressure drop across a physical restriction. Turbine meters generate pulses as fluid turns a rotor, making frequency proportional to flow. Thermal mass meters detect fluid flow by measuring heat transfer rates. Hinged vane meters translate mechanical displacement into electrical resistance using a potentiometer. These match the designated operating principles.

171. (A) Voltage-controlled current source (VCCS)
A voltage-controlled current source is an electronic circuit designed to generate an output current that is directly proportional to an input voltage. This type of signal conditioning is highly useful for transmitting signals over long distances, as current-mode signals are immune to line resistance and voltage attenuation, unlike traditional voltage-mode signals.

172. (C) External power supplied to a passive sensor to generate an output signal.
Passive sensors, such as strain gauges, resistance temperature detectors, and thermistors, do not generate their own electrical signals. Excitation refers to the external voltage or current supplied to these sensors to enable operation. This external electrical power allows the sensor to convert changes in its physical parameters into a measurable voltage output.

173. (D) Strain gauge
Strain gauges are passive resistive devices that do not generate electricity. To measure changes in resistance caused by mechanical strain, an external excitation voltage or current must be applied, typically through a Wheatstone bridge. Without this external electrical excitation, the changes in resistance cannot be converted into a measurable output voltage signal.

NODIA

174. (C) Thermocouple
Thermocouples are active, self-generating sensors that operate on the Seebeck effect. When a temperature gradient exists across two dissimilar metals, a proportional thermoelectric voltage is generated naturally without any external power source. This characteristic distinguishes thermocouples from passive sensors like resistance temperature detectors and thermistors, which

require continuous external electrical excitation to function.

175. (B) It eliminates errors from mismatched lead-wire resistances.
In a three-wire configuration, any difference or mismatch in lead-wire resistances directly introduces measurement errors. A four-wire Kelvin configuration separates the excitation current path entirely from the voltage-sensing path. Because virtually no current flows through the sensing leads, wire resistance mismatches do not create voltage drops, completely eliminating lead-wire errors over long distances.

176. (D) To convert continuous analog voltages into discrete digital numbers.
Physical parameters are measured as continuous analog signals, which computers and microprocessors cannot process directly. The fundamental role of an analog-to-digital converter is to sample these continuous analog voltages at discrete time intervals and convert them into proportional digital numbers. This step enables digital signal processing, storage, and analysis in computer-based systems.

177. (C) 100
To match the output of a transducer to the input span of an analog-to-digital converter, amplification is required. The gain is calculated by dividing the maximum input voltage of the converter by the maximum output voltage of the sensor. Dividing five volts by fifty millivolts results in a required amplification factor of exactly one hundred.

178. (C) Adding or subtracting a constant DC level.
Offsetting is a basic signal conditioning operation that shifts the entire baseline of an analog signal. It involves adding or subtracting a constant direct current voltage level to the signal. This process is commonly used to align bipolar sensor outputs with unipolar input ranges of standard analog-to-digital converters, preventing clipping or signal loss.

179. (A) Both gain adjustment and DC offsetting.
The sensor outputs a four-volt span centered at zero, while the converter requires a five-volt span starting at zero. To interface these devices, the signal must first be amplified by a gain of one point twenty-five to match the span. A positive direct current offset voltage is then added to shift the range to positive values.

180. (B) Sensor → Amplifier → Filter → ADC
In a typical data acquisition system, the low-level signal from the sensor is first amplified to increase its amplitude and maximize dynamic range. The amplified signal is then passed through a low-pass anti-aliasing filter to remove high-frequency noise and prevent aliasing. Finally, this conditioned, band-limited analog signal is digitized by the analog-to-digital converter.

181. (B) Sampling at less than twice the signal's highest frequency.
Aliasing is a distortion that occurs when an analog signal is sampled too slowly. If the sampling frequency is less than twice the highest frequency component present in the signal, those high-frequency components overlap with lower frequencies. This causes high-frequency noise to appear as false low-frequency signals, which cannot be digitally filtered out later.

182. (C) At least twice its maximum frequency.
The Nyquist-Shannon sampling theorem states that to reconstruct an analog signal perfectly from its discrete samples, the sampling rate must be strictly greater than twice the highest frequency component present in that signal. This threshold is known as the Nyquist rate. Sampling below this limit introduces irreversible aliasing distortion into the digitized data.

183. (D) The bit resolution of the system's internal ADC.
The resolution of a digital data acquisition system represents the smallest change in analog voltage that can be detected. This parameter is directly determined by the number of bits in the analog-to-digital converter. A higher bit resolution divides the input voltage range into a greater number of discrete steps, providing finer voltage measurement capability.

184. (B) 2.44 mV
A twelve-bit converter divides its input range into two to the power of twelve, which equals four thousand ninety-six discrete levels. For a ten-volt input range, the resolution is calculated by dividing ten volts by four thousand ninety-six. This calculation yields a voltage step size of approximately two point forty-four millivolts per digital code.

Click Here to Buy book on Amazon

185. (B) Lacks any physical connection to absolute system ground.
A floating signal source is an electrical source that has no direct connection or low-impedance path to the local earth or system ground. Examples include batteries, thermocouples, and isolated transformer outputs. Because both terminals are electrically isolated from the ground, the common-mode potential of the source can drift if not properly referenced.

186. (B) A DC bias path to ground for input leakage currents.
When connecting a floating source to a differential amplifier, the input terminals are isolated from ground. The amplifier's input stage requires small bias currents to function. Without a dedicated direct current path to ground, these bias currents will charge the input capacitance, causing the common-mode voltage to drift and saturate the amplifier.

187. (A) Beta (β) value
Negative temperature coefficient thermistors exhibit an exponential relationship between resistance and temperature. This characteristic curve is mathematically modeled using a constant known as the Beta value. This value, expressed in Kelvin, represents the sensitivity of the thermistor material over a specific temperature range and is crucial for calibrating and linearizing the sensor output.

188. (C) The thermoelectric voltage generated per unit temperature difference.
The Seebeck coefficient is a physical property that measures the magnitude of an induced thermoelectric voltage in response to a temperature difference across a material. It is defined as the ratio of the generated voltage to the temperature gradient. This coefficient is the fundamental operating principle behind thermocouples used for temperature measurement.

189. (A) Sensor → Transmitter → Power Supply → Receiver
In a standard current loop system, the physical parameter is first measured by the sensor. The transmitter converts this reading into a proportional current signal between four and twenty milliamps. The loop is energized by a direct current power supply, and the receiver detects the current, typically converting it to voltage across a resistor.

190. (B) II, IV, I, III
Chopper amplification operates by first modulating a low-frequency or direct current input signal into a high-frequency alternating current carrier wave. This modulated signal is then amplified using an alternating current-coupled amplifier, which naturally eliminates low-frequency drift. The amplified signal is synchronously demodulated back to direct current and low-pass filtered to reconstruct the smooth output.

191. (B) Signal transmission without direct ohmic connection between input and output.
Galvanic isolation is a design technique that prevents direct electrical current flow between two distinct sections of a system while still allowing signal or power transfer. Signals are typically transmitted across this non-conductive barrier using optical, magnetic, or capacitive methods. This isolation protects equipment from high voltages and eliminates problematic ground loops.

192. (D) Multiplexing the analog channels on the isolated side before amplification.
To handle multiple isolated sensor channels using a single isolation amplifier, the signals must be multiplexed on the isolated input side. This arrangement allows individual channels to be sequentially switched into the isolation amplifier stage. It maintains the integrity of the galvanic isolation barrier while significantly reducing system cost and complexity by sharing components.

193. (A) pH sensors have extremely high source impedance, making them sensitive to current draw.
Chemical pH sensors have an exceptionally high internal source impedance, often exceeding several hundred megohms. Any small current drawn by the measurement circuit will flow through this high impedance, generating a massive voltage drop and severe measurement errors. Using an amplifier with extremely high input impedance minimizes current draw, preserving the actual sensor voltage.

NODIA

194. (C) Balancing the bridge so the potential difference between output nodes is zero.
A Wheatstone bridge relies on the null measurement principle, which involves adjusting the bridge resistors until the electrical potential difference between the output nodes is exactly zero. When the bridge is perfectly balanced, no current flows through the central detector. This balanced condition provides an accurate baseline for detecting tiny resistance variations.

195. (A) A full-bridge uses four active gauges, while a half-bridge uses only two.
The primary structural difference between these two configurations lies in the number of active strain gauges used. A full-bridge configuration incorporates four active gauges, with one in each of the four arms of the Wheatstone bridge. A half-bridge utilizes only two active gauges, with the remaining arms completed by fixed reference resistors.

196. (D) Act as a high input impedance, low output impedance unity-gain buffer.
A voltage follower is an operational amplifier circuit configured with a feedback loop that yields unity gain. Its primary purpose is impedance matching in signal conditioning paths. It presents an extremely high input impedance to prevent loading of sensitive sensors, while providing a very low output impedance to drive subsequent measurement or filtering stages.

197. (B) Differential-mode noise generated by the sensor itself.
Instrumentation amplifiers are designed with a high common-mode rejection ratio to suppress common-mode noise and ground loops. They also feature high input impedance to prevent loading. However, differential-mode noise appears directly between the two input terminals, identical to the desired signal. Consequently, the amplifier cannot distinguish this noise from the signal and will amplify it.

198. (C) A 1-volt measurement error.
In voltage-mode transmission, the signal is represented by the potential difference arriving at the receiver. If wire resistance causes a one-volt drop along the cable, the voltage reaching the receiver will be exactly one volt lower than the transmitted value. This drop directly introduces a significant, uncompensated one-volt measurement error at the receiving terminal.

199. (D) No error, provided loop compliance voltage limits are not exceeded.
In a current loop system, the transmitter dynamically adjusts its output voltage to maintain the correct loop current regardless of line resistance. If a voltage drop occurs along the wire, the transmitter automatically increases its output potential to compensate. As long as the compliance voltage limit is not exceeded, the current remains accurate, resulting in zero error.

200. (A) The maximum voltage a transmitter can output to drive loop current.
Compliance voltage represents the maximum output voltage that a current loop transmitter can generate to maintain the desired current through the loop. This voltage must be high enough to overcome the total resistance of the transmission wires, receiver shunt resistors, and connection terminals. Exceeding this limit prevents the transmitter from delivering the required current.

201. (B) Power Supply Rejection Ratio
The power supply rejection ratio is a critical parameter that quantifies an operational amplifier's ability to maintain its output voltage independent of fluctuations in its supply voltages. A higher ratio indicates that noise or voltage ripple present on the power supply lines will be highly attenuated and will not corrupt the low-level signal path.

202. (B) The maximum output voltage rate of change, limiting high-frequency performance.
Slew rate is the maximum rate of change of an operational amplifier's output voltage, typically measured in volts per microsecond. This parameter is limited by internal currents charging the compensation capacitor. When input signals demand a faster rate of change than the slew rate can provide, the output becomes distorted, restricting high-frequency performance.

203. (A) Pass signals below 100 Hz and attenuate higher frequencies.
A low-pass filter with a cutoff frequency of one hundred hertz is designed to allow lower-frequency signals to pass with minimal attenuation. Frequencies above this threshold are progressively attenuated as they extend further into the stopband. This frequency-selective behavior is essential for removing high-

Downloaded from www.pdf.tube

frequency noise while preserving the integrity of low-frequency sensor data.

204. (C) Unwanted signal leakage between adjacent multiplexer channels.
Cross-talk refers to the unwanted capacitive, inductive, or resistive coupling that occurs between adjacent channels in a multiplexed data acquisition system. When one channel is active, its voltage can leak into neighboring channels through parasitic paths. This leakage corrupts the measurements of inactive channels, reducing overall system accuracy and signal isolation.

205. (D) Using low source impedances and allowing adequate settling time.
Cross-talk in multiplexed systems is exacerbated by high source impedances and rapid switching. Using low source impedances helps discharge parasitic capacitances quickly. Additionally, allowing adequate settling time after switching channels ensures that any transient voltages decay completely before the analog-to-digital converter samples the signal, minimizing interference between adjacent measurement paths.

206. (C) $V = -\frac{Q}{C_f}$

A charge amplifier converts the electrical charge produced by a piezoelectric sensor into a proportional voltage. The circuit uses an operational amplifier with a feedback capacitor. The charge is accumulated on this capacitor, and because of the virtual ground at the inverting input, the output voltage is mathematically defined as negative charge divided by feedback capacitance.

207. (B) Static forces or continuous DC pressures.
Piezoelectric materials generate an electrical charge only when subjected to dynamic mechanical stress. Under a static load, the generated charge will slowly leak away through the internal resistance of the sensor, the connection cables, and the amplifier inputs. Consequently, these sensors cannot maintain a stable output for static forces or continuous direct current measurements.

208. (D) It has a much higher gauge factor (sensitivity).
Semiconductor strain gauges utilize the piezoresistive effect in silicon, which yields a significantly higher gauge factor than traditional metallic foil gauges. This elevated sensitivity allows them to detect extremely small physical deformations, producing a much larger change in electrical resistance. This characteristic is highly advantageous for measuring micro-strain in low-load sensor applications.

NODIA

209. (A) An instrumentation amplifier.
The resistance changes in a strain gauge are extremely small, producing low-level differential voltages across a Wheatstone bridge. An instrumentation amplifier is ideal for this application because it offers high input impedance, which prevents loading, and a high common-mode rejection ratio, which rejects common-mode noise while highly amplifying the tiny differential strain signal.

210. (A) Both A and R are true and R is the correct explanation of A.
Placing a low-pass filter immediately before an analog-to-digital converter is a standard engineering practice. This filter functions as an anti-aliasing barrier, restricting the input signal bandwidth. By attenuating all frequency components above the Nyquist limit, it prevents high-frequency noise from folding back into the lower frequency spectrum, ensuring accurate digitization.

211. (A) An IC temperature sensor mounted on the connection block.
In modern thermocouple measurement modules, cold-junction compensation is performed by measuring the temperature of the terminal block where the thermocouple wires connect. An integrated circuit temperature sensor is mounted directly on this isothermal connection block. This measurement is then used by the system software to calculate and compensate for the reference junction voltage.

212. (D) It maintains all terminals at the same temperature to eliminate thermal gradients.
An isothermal terminal block is constructed from materials with high thermal conductivity to ensure that all connection terminals remain at a uniform temperature. By eliminating thermal gradients across the terminals, it prevents the creation of unwanted thermocouple junctions where the sensor alloys meet copper traces, which is critical for accurate cold-junction compensation.

213. (B) The alloy combination, determining temperature range and sensitivity.
The letter designations assigned to thermocouples represent specific combinations of metal alloys used in their construction. Each alloy pair exhibits unique thermoelectric characteristics, which determine the sensor's temperature measurement range, chemical compatibility, and voltage sensitivity. These standardized classifications help engineers select the appropriate thermocouple type for specific industrial environments.

214. (C) Type K
The Type K thermocouple is the most widely used general-purpose temperature sensor in industrial applications. It is constructed from a positive leg of Chromel alloy and a negative leg of Alumel alloy. This combination provides a wide temperature range, good resistance to oxidation, and a relatively linear voltage output at a highly cost-effective price.

215. (D) The same alloys as the thermocouple to prevent unintended thermoelectric junctions.
Thermocouple extension wires must be fabricated from the same alloys as the thermocouple itself. If different metals like copper are used to connect the sensor to the terminal block, new thermoelectric junctions will be created at the connection points. These additional junctions generate unwanted voltages that distort the primary temperature measurement.

216. (A) NTC Thermistor
Thermistors exhibit a highly non-linear, exponential relationship between resistance and temperature. The Steinhart-Hart equation is a third-order polynomial formula used to model this relationship with exceptional accuracy over a wide temperature span. It is widely implemented in microcontroller software to linearize the readings obtained from negative temperature coefficient thermistors.

217. (B) 100 Ω
The platinum resistance temperature detector classification known as PT100 is defined by its nominal electrical resistance at a standard reference temperature. This sensor is calibrated to exhibit exactly one hundred ohms of electrical resistance at zero degrees Celsius. Its resistance increases predictably and linearly as the temperature rises above this baseline.

218. (B) Self-heating error, raising the RTD temperature above ambient.
Resistance temperature detectors are passive sensors requiring an excitation current to generate a measurable voltage. When this current is too high, the electrical power dissipated within the sensor element generates internal heat. This self-heating raises the temperature of the sensor above the ambient environment, introducing a positive measurement error.

219. (A) 100 μA to 1 mA
To minimize the effects of self-heating in a resistance temperature detector, the electrical power dissipated by the sensor must be kept very low. This is achieved by limiting the excitation current to a range between one hundred microamps and one milliamp. This low current level prevents significant internal heating while providing a measurable voltage.

220. (B) P-3, Q-4, R-1, S-2
Optical isolation utilizes light-emitting diodes and photodetectors to transfer signals. Magnetic isolation uses inductively coupled transformer coils to transfer alternating current modulated signals. Capacitive isolation utilizes high-frequency modulation across barrier capacitors. Galvanic isolation is the general term for breaking all direct direct current conduction paths between circuits while permitting signal transfer.

221. (D) Protect the patient from hazardous electrical leakage currents.
In medical electronics like electrocardiograms, electrodes are placed in direct contact with the patient's skin. An isolation amplifier is essential to break any direct electrical path between the patient and high-voltage power mains. This galvanic isolation prevents hazardous electrical leakage currents from flowing through the patient, ensuring safety during clinical measurements.

222. (C) A series capacitor at the input that blocks DC and passes only AC signals.
An alternating current-coupled amplifier incorporates a capacitor in series with its input signal path. This series capacitor acts as an open circuit to direct current voltages, effectively blocking any constant offset or baseline drift. However, it allows alternating current signals to pass through, enabling the amplifier to process only the dynamic, changing signal components.

Click Here to Buy book on Flipkart

223. (B) To block the large DC static offset, preventing saturation and enabling high AC gain.
When a tiny dynamic signal is superimposed on a massive constant offset, amplifying the entire signal directly would cause the amplifier to saturate. Alternating current coupling uses a series capacitor to block this large static direct current potential. This allows the amplifier to focus entirely on and highly amplify the small dynamic ripple.

224. (D) An RTD
The Callendar-Van Dusen equation is a mathematical formula that describes the relationship between resistance and temperature for platinum resistance temperature detectors. While platinum is highly linear, it still exhibits small non-linearities over wide temperature ranges. This equation provides the accurate curve-fitting coefficients required to linearize these sensor measurements.

225. (A) Magnetic flowmeter (Magmeter)
Magnetic flowmeters operate directly on Faraday's law of electromagnetic induction. When a conductive fluid flows through a magnetic field generated by the meter, a voltage is induced across the fluid. This induced voltage, which is perpendicular to both the flow direction and the magnetic field, is directly proportional to fluid velocity.

226. (C) Conductive
Because magnetic flowmeters rely on Faraday's law of electromagnetic induction to function, the fluid being measured must have a minimum level of electrical conductivity. If the fluid is non-conductive, such as deionized water or hydrocarbons, no voltage will be induced across the electrodes, rendering the flowmeter incapable of taking a measurement.

227. (A) $Q \propto \sqrt{\Delta P}$
In differential pressure flow measurement devices like orifice plates, the fluid velocity is related to pressure drop. According to Bernoulli's equation, the volumetric flow rate is directly proportional to the square root of the differential pressure drop across the restriction. This non-linear relationship must be linearized during signal conditioning.

228. (D) Linearize the flow-to-pressure relationship.
Because the volumetric flow rate through an obstruction is proportional to the square root of the differential pressure drop, the raw pressure signal is non-linear. Square root extraction is a signal conditioning step that applies a mathematical square root operation to the measured pressure value, linearizing the relationship for control and display.

229. (B) An AC voltage with frequency scaled to gear speed.
A variable reluctance speed sensor consists of a permanent magnet and a sensing coil positioned near a rotating ferrous gear. As the gear teeth pass the sensor, they alter the magnetic reluctance, inducing an alternating current voltage in the coil. The frequency of this resulting signal is directly proportional to the rotational speed.

230. (B) Analog Input → Delta-Sigma Modulator → Digital Filter/Decimator → Digital Output
In a Delta-Sigma converter, the continuous analog input is first converted into a high-speed, single-bit stream by the modulator using oversampling. This raw bitstream is then processed by a digital filter and decimator, which filters out high-frequency noise and reduces the data rate, producing a high-resolution, multi-bit digital output.

231. (D) High resolution and built-in digital anti-aliasing.
Delta-Sigma converters employ oversampling and noise-shaping techniques to achieve exceptionally high resolution, often exceeding twenty-four bits. This oversampling relaxes the requirements for analog anti-aliasing filters, as the built-in digital decimation filters effectively remove high-frequency noise, making them superior to successive approximation converters for high-precision, low-frequency measurements.

232. (A) A conductive extension of one plate, changing the active area.
In capacitive level sensing, the probe acts as one plate of a capacitor and the tank wall acts as the other. If the liquid is conductive, it acts as an extension of the grounded wall plate. As the liquid level rises, it changes the active surface area of the capacitor, producing a proportional capacitance change.

Downloaded from www.pdf.tube

233. (B) Light refracts into the liquid because the external refractive index matches the prism.
Optical level sensors operate on the principle of total internal reflection. When the prism is surrounded by air, light reflects internally and returns to the detector. However, when liquid contacts the prism, its refractive index matches the prism, causing the light to refract into the liquid instead of reflecting, signaling the presence of liquid.

234. (B) Translates spring compression into a wiper's movement over a resistor.
A spring-driven rheostat is a legacy mechanical transducer used for force measurement. When an external force is applied, it compresses a calibrated internal spring, causing a physical displacement. This displacement is mechanically coupled to a wiper that slides along a resistive track, converting the mechanical displacement into a proportional change in electrical resistance.

235. (A) By summing parallel currents in hardware or processing separate ADC channels in software.
In multi-sensor platforms, the individual signals must be combined to determine the total load. This is commonly achieved by wiring the load cells in parallel to sum their output currents directly in hardware. Alternatively, each sensor output can be digitized by separate converter channels and summed mathematically in the system software.

236. (C) Directly proportional to the input voltage.
A voltage-to-frequency converter is an electronic integration device that generates a continuous sequence of electrical pulses. The internal design ensures that the rate of these output pulses, or frequency, is directly proportional to the magnitude of the analog input voltage. This linear relationship is crucial for accurate signal conversion and transmission.

237. (D) Frequency is unaffected by amplitude degradation, preserving measurement accuracy.
When transmitting analog voltage signals over long distances, wire resistance and electromagnetic noise cause amplitude degradation and attenuation. By converting the voltage into a frequency signal, the information is encoded in the timing of the pulses. Because frequency is unaffected by amplitude attenuation, this technique preserves measurement accuracy over long transmission lines.

NODIA

238. (C) By counting the incoming pulses over a defined, precise gating period.
To convert a frequency-encoded signal back into a digital value, a microcontroller utilizes its internal timer and counter peripherals. By counting the number of pulses received during a precisely controlled gating time window, the system determines the frequency. This counted value is directly proportional to the original analog voltage input.

239. (B) The length of the counting time window, balancing resolution against sample rate.
The resolution of a frequency-counting system depends on the number of pulses accumulated during the measurement. Increasing the length of the counting time window allows more pulses to be counted, which directly improves resolution. However, a longer counting window reduces the overall sampling rate, requiring a trade-off between speed and precision.

240. (B) II, I, III
Filters are arranged in physical sequence from the input stage to the software stage. Passive radio frequency interference filters at the input handle the highest frequencies. This is followed by the active anti-aliasing filter, which has a lower cutoff frequency designed for the converter. Finally, the digital moving average filter in software has the lowest cutoff frequency.

241. (A) The shield uses high-permeability magnetic material or the wires are twisted.
Standard non-magnetic conductive shields, such as copper or aluminum braid, are highly effective against electrostatic fields but offer virtually no protection against low-frequency magnetic fields. To mitigate magnetic interference, the shield must be made of high-permeability magnetic material to redirect magnetic flux, or the signal wires must be twisted to cancel induced currents.

242. (C) Coaxial cables with ungrounded shields
Ground loops are broken by preventing direct electrical current paths between separate ground points. Optocouplers, isolation transformers, and differential instrumentation amplifiers are effective methods to achieve this isolation. Using a coaxial cable with an ungrounded shield is ineffective because it does not provide galvanic isolation or a proper differential measurement path.

243. (A) At a single end to avoid creating loop paths.
To prevent ground loop currents from flowing through the shield of a sensitive signal cable, the shield must be grounded at only one end. If grounded at both ends, any potential difference between the ground points will drive a current through the shield, coupling noise into the signal wires. Single-point grounding eliminates this path.

244. (D) A low-impedance trace surrounding the input node, driven to its exact potential to stop leakage.
In low-level current measurement circuits, PCB surface contamination can cause microscopic currents to leak from high-voltage lines to sensitive nodes. A guard is a low-impedance conductive trace that completely surrounds the sensitive node. By driving this guard trace to the exact electrical potential of the node, the voltage gradient is eliminated, stopping leakage.

245. (B) A high-impedance pH probe.
Active guarding is critical when dealing with sensors that have exceptionally high source impedances, such as pH probes. These sensors are highly vulnerable to extremely small surface leakage currents on the circuit board, which can cause massive measurement errors. Active guarding eliminates the voltage difference between the input trace and its surroundings, preventing leakage.

246. (C) It forms a capacitive divider with the sensor, attenuating the signal.
Piezoelectric sensors are capacitive signal sources that produce a charge. The cable connecting the sensor to the amplifier introduces parasitic capacitance in parallel with the sensor. This parasitic capacitance acts as a capacitive voltage divider, which directly reduces the voltage amplitude reaching the amplifier, leading to significant signal attenuation.

247. (B) Cable capacitance would otherwise attenuate the measurement signal.
Voltage-mode amplifiers are highly sensitive to the capacitance of the input cable connected to a piezoelectric sensor. Because the cable capacitance is in parallel with the sensor, longer cables increase this capacitance, which attenuates the signal voltage reaching the amplifier. Placing the amplifier close to the sensor minimizes cable length and preserves signal integrity.

248. (A) A maximally flat response in the passband.
The Butterworth filter is designed to provide a maximally flat amplitude response throughout its passband. This means that there is no ripple in the passband, and the gain decreases smoothly toward the cutoff frequency. This characteristic is highly desirable in instrumentation applications where signal amplitudes must be preserved accurately.

249. (B) -20 dB/decade
A first-order resistor-capacitor low-pass filter is the simplest analog filter configuration. Because it contains a single reactive component, it exhibits a frequency roll-off rate of minus twenty decibels per decade in its stopband. This relatively gentle slope means that signal frequencies ten times higher than the cutoff frequency are attenuated by twenty decibels.

250. (B) Second-order
The roll-off rate of an analog filter in the stopband is directly determined by its mathematical order. Each order adds twenty decibels per decade of attenuation. To achieve a steeper roll-off of minus forty decibels per decade, a second-order filter is required, which incorporates two reactive poles in its circuit design.

251. (A) Modulates the excitation current to counteract the non-linear RTD curve.
Resistance temperature detectors exhibit a slight non-linear resistance change over temperature. Hardware linearization can be achieved by utilizing positive feedback to modulate the sensor's excitation current. As the temperature and sensor resistance rise, the feedback loop increases the excitation current slightly. This dynamic adjustment compensates for the non-linearity, producing a linear voltage output.

252. (C) Switch resistors into the op-amp feedback path at set levels to alter gain.
A piecewise-linear approximation circuit uses diodes to approximate non-linear curves. As the input voltage increases, specific diodes turn on at predetermined threshold levels, switching additional resistors into the feedback loop of an operational amplifier. This action changes the amplifier's gain at different operating regions, creating a piecewise-linearized approximation of the non-linear transfer function.

Click Here to Buy book on Amazon

253. (D) Increase its output voltage to maintain the loop current.
In a four-to-twenty milliamp current loop, the transmitter is designed to maintain a precise current regardless of loop resistance. If the line resistance increases, the transmitter automatically increases its output terminal voltage to overcome the added impedance. This ensures that the current flowing through the loop remains accurate according to Ohm's law.

254. (C) Power the internal transmitter electronics.
A loop-powered, two-wire transmitter is powered directly by the current loop itself. The four-milliamp "live zero" represents the minimum current that always flows through the loop. The transmitter uses this continuous baseline current to power its internal sensing, amplification, and processing electronics, eliminating the need for an external power supply.

255. (B) A precision shunt resistor.
To interface a four-to-twenty milliamp current loop with a standard voltage-input converter, a precision shunt resistor is placed across the input terminals. As the loop current passes through this resistor, it generates a proportional voltage drop according to Ohm's law. A two hundred fifty ohm resistor, for example, converts the current into a one-to-five volt signal.

256. (D) At the junction where thermocouple wires meet copper PCB traces.
Cold-junction compensation is based on the assumption that the reference temperature sensor is located at the exact physical point where the thermocouple wires connect to the copper circuit board traces. This ensures that the reference sensor measures the true temperature of this junction, allowing the system to mathematically correct for the cold-junction voltage.

257. (A) High-speed switching (thousands of channels per second) is required.
Solid-state CMOS analog multiplexers utilize electronic semiconductor switches rather than mechanical contacts. Consequently, they are selected when high-speed switching is required, as they can transition between channels in microseconds. Unlike mechanical relays, they do not suffer from contact wear, bounce, or low switching rates, making them ideal for rapid data acquisition.

258. (C) Provide high common-mode rejection by switching a charged capacitor from sensor to ADC.
Flying-capacitor multiplexing is a technique used to measure low-level differential signals in the presence of high common-mode voltages. A capacitor is first connected to the sensor to acquire the differential charge. It is then completely disconnected from the sensor and switched to the converter input, providing excellent common-mode rejection and galvanic isolation.

NODIA

259. (A) It acts as a Wheatstone bridge on a silicon diaphragm.
Piezoresistive silicon pressure sensors are fabricated by diffusing resistive elements directly onto a micro-machined silicon diaphragm. These resistors are arranged in a Wheatstone bridge configuration. When pressure deforms the diaphragm, the resistors experience stress and change their resistance, unbalancing the bridge and producing a differential voltage proportional to the applied pressure.

260. (D) The physical break in the resistive track between rotational limits.
In rotary potentiometers, a dead band refers to the small physical gap in the circular resistive track near the rotational limits where the wiper loses contact. Within this region, the sensor cannot measure angular position, and the output signal becomes open or undefined, representing a limitation in the mechanical design of the sensor.

261. (B) Minimal, typically consisting of an anti-aliasing filter and a buffer.
High-level semiconductor sensors output robust analog signals, such as zero to five volts, which match the input range of standard converters. Because these signals are already amplified and have low source impedance, they require minimal signal conditioning. Typically, only a simple unity-gain buffer and a low-pass anti-aliasing filter are needed before digitization.

262. (C) Frequency signals are immune to amplitude noise during telemetry or slip ring transmission.
On rotating machinery shafts, signals must be transmitted across sliding contacts or wireless telemetry links, which introduce substantial electrical noise and amplitude variation. Converting the strain gauge signal into a frequency prevents this noise from corrupting

the measurement. Because the frequency remains unchanged by amplitude attenuation, accurate data transmission is preserved.

263. (D) An inline orifice plate.
In differential pressure flow measurement, an obstruction must be placed in the pipe to create a localized pressure drop. A standard orifice plate, which is a flat metal plate with a precise hole, is commonly clamped inline. The resulting pressure difference across this restriction is measured and used to calculate the fluid flow rate.

264. (A) The heat transfer rate from a heated sensor to the flowing gas.
Thermal anemometers measure gas flow rates by utilizing a heated sensing element exposed to the fluid stream. As the gas flows past the sensor, it removes heat from the element. The rate of heat transfer is directly related to the mass flow rate of the gas, allowing the sensor to determine flow velocity.

265. (B) Hysteresis, friction, and mechanical wear in the linkage.
In float-driven level sensors, mechanical linkages translate the vertical movement of the float into the rotation of a potentiometer. The primary sources of measurement error in these systems are friction, mechanical wear over time, and hysteresis within the joints. These mechanical limitations introduce inaccuracies that degrade the precision of the electrical output.

266. (B) NTC Thermistor
Negative temperature coefficient thermistors exhibit an extremely large resistance change per degree of temperature variation compared to other sensors. This exceptional sensitivity makes them ideal for high-resolution differential thermometers operating over narrow temperature spans, where detecting minute temperature changes is critical for the accuracy of the overall measurement system.

267. (A) The slow output voltage variation over time or temperature under zero input.
Zero drift in a direct current amplifier refers to the slow, unwanted variation in the output voltage over time or changes in temperature when the input signal is held at zero. This drift is caused by internal component aging and temperature dependencies, necessitating correction techniques like chopping or auto-zeroing.

268. (C) DC offset and low-frequency zero drift.
Chopper amplifiers are specifically designed to eliminate direct current offset voltages and low-frequency zero drift. By modulating the low-frequency input signal into an alternating current carrier, amplifying it, and then demodulating it, the amplifier bypasses the low-frequency noise and drift inherent in direct current stages, ensuring high stability.

269. (D) High internal source impedance.
The loading effect occurs when a voltmeter draws current from the circuit under test, altering the voltage being measured. This effect is most severe when measuring a circuit with high internal source impedance, as the voltmeter's input resistance forms a voltage divider with the source, significantly reducing the voltage at the measurement terminals.

270. (C) A common-mode input voltage will create an unintended output voltage change.
In a practical operational amplifier, the common-mode rejection ratio is finite rather than infinite. This finite rejection means that the amplifier cannot perfectly cancel out identical signals present on both inputs. Consequently, any changes in the common-mode input voltage will produce an unwanted change in the output voltage, introducing measurement errors.

****

Downloaded from www.pdf.tube

CHAPTER 03
Process Control Instrumentation

2017

1. Which variable is actively adjusted by the controller to minimize the error signal in a closed-loop system?
(A) Manipulated variable
(B) Controlled variable
(C) Disturbance variable
(D) Setpoint variable

2006

2. What constitutes the error signal in a standard feedback control block diagram?
(A) The sum of the manipulated variable and the current setpoint
(B) The ratio of the controlled variable to the manipulated variable
(C) The difference between the setpoint and the controlled variable
(D) The time derivative of the controlled variable in the process

2002

3. In a process control system, the primary function of the measuring element (sensor) is to convert the controlled variable into a corresponding signal for the:
(A) Comparator
(B) Actuator element
(C) Final control element
(D) Manipulated process

2007

4. Identify the correct statement regarding closed-loop process control.
(A) It fails to dynamically compensate for unmeasured external disturbances.
(B) It relies purely on the mathematical model without using actual feedback.
(C) It responds faster than open-loop control while guaranteeing stability.
(D) It compares the measured output to the setpoint to adjust the process input.

2019

5. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): A closed-loop control system is generally more accurate than an open-loop system.
Reason (R): The closed-loop system utilizes feedback to compensate for external disturbances and internal variations.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

6. Which of the following is an INCORRECT representation of a closed-loop control system component?
(A) Setpoint: The desired target value for the process
(B) Controller: The intelligence unit calculating the required corrective action
(C) Actuator: The device that measures the current state of the process
(D) Final Control Element: The device executing the control command

2012

7. Which pair correctly matches the control system terminology with its function?
(A) Load variable – Represents an external disturbance managed by the operator
(B) Comparator – Executes the final physical adjustment of flow in the process
(C) Setpoint – Represents the physical quantity being maintained by the process
(D) Transducer – Converts one form of energy to another for measurement purposes

2013

8. Identify the INCORRECT pair regarding block diagram algebra.
(A) Moving a takeoff point from ahead of a block to behind it – Multiply the takeoff branch by the block's transfer function
(B) Blocks in series – Overall transfer functions are multiplied together in sequence
(C) Blocks in parallel – Combined transfer functions are added together directly

NODIA

(D) Feedback loop – Closed-loop transfer function is $\frac{G}{1-GH}$ for positive feedback

2016

9. Match the closed-loop terminology (List I) with its definition (List II).

List I: Closed-loop terminology

P. Controlled Variable

Q. Manipulated Variable

R. Setpoint

S. Disturbance

List II: Definition

1. Desired output
2. Measured output
3. Altered input
4. Unwanted input

(A) P-1, Q-4, R-2, S-3

(B) P-2, Q-3, R-1, S-4

(C) P-3, Q-2, R-4, S-1

(D) P-2, Q-1, R-3, S-4

2008

10. All of the following are essential components of a standard feedback control loop EXCEPT:

(A) Measuring transmitter

(B) Feedforward predictor

(C) Final control element

(D) Error detector

2008

11. What is the most significant economic incentive for implementing advanced process control?

(A) Operating closer to process constraints safely

(B) Reducing the frequency of routine laboratory analysis of product streams

(C) Maximizing the production of low-value byproducts

(D) Minimizing the initial capital cost of physical storage tanks

2013

12. Consider the following statements regarding process degrees of freedom:

I. Degrees of freedom equal the number of variables minus the number of independent equations.

II. Control degrees of freedom determine how many independent controllers can be deployed.

III. Adding a perfectly operating control loop increases the degrees of freedom by one.

Which of the above statements are correct?

(A) I and II

(B) I and III

(C) II and III

(D) I only

2007

13. If a process mathematically exhibits zero degrees of freedom, what does this indicate about its control?

(A) The process is highly controllable through advanced multivariable techniques.

(B) The process requires exactly one manipulated variable for dynamic stability.

(C) The system exhibits infinite gain and phase margins under closed-loop control.

(D) The system is fully specified by its equations, leaving no variables available for manipulation.

2006

14. An over-specified process model results when the mathematical formulation has negative degrees of freedom. What is the immediate effect on system resolution?

(A) The physical system yields infinite mathematically valid solutions.

(B) The process immediately requires additional control valves to operate.

(C) The mathematical equations become inconsistent or highly redundant.

(D) The system transitions directly into a non-linear adaptive control mode.

2009

15. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Process control systems are essential for maintaining safety boundaries in chemical plants.

Reason (R): They strictly maximize the number of mathematical degrees of freedom in the operating process.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

2003

16. Consider the following statements regarding incentives for process control:

I. Enhances product quality consistency

II. Increases variability in the controlled variables

III. Reduces equipment lifecycle through constant valve adjustments

Click Here to Buy book on Flipkart

IV. Ensures safe operation within environmental limits

Which of the above statements are INCORRECT?

(A) I, II and IV
(B) II and III
(C) I and III
(D) II, III and IV

2021

17. How does the control degree of freedom compare to the dynamic degree of freedom in a process?

(A) Control degrees equal dynamic degrees minus externally fixed variables.
(B) Control degrees of freedom exceed dynamic degrees of freedom under transient conditions.
(C) Dynamic degrees of freedom are applicable only to steady-state operating scenarios.
(D) They represent identical mathematical values across standard process designs.

2021

18. Which incentive is considered most relevant when justifying the cost of a new control system installation?

(A) The systematic reduction of the underlying mathematical model complexity
(B) A significant reduction in routine preventive maintenance on mechanical valves
(C) The reduction in process variability allowing optimal setpoint shifts
(D) The aesthetic improvement of the physical operator control room interface

2002

19. Match the process type (List I) with its typical degree of freedom characteristic (List II) assuming standard design.

List I: Process type

P. Liquid tank with pump
Q. Binary distillation
R. Simple heat exchanger
S. CSTR

List II: Degree of freedom characteristic

1. Complex multiple DOF
2. Temperature & Flow dependent
3. Level dependent
4. Residence time & Temp dependent

(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-2, Q-4, R-1, S-3

2006

20. Consider the following statements concerning the mathematical modeling of degrees of freedom:

I. Variables (N_v) include all internal fluxes and conditions.
II. Equations (N_e) include mass and energy balances.
III. Parameters are treated as variables in DOF analysis.
IV. External inputs are subtracted to find control DOF.

Which of the above statements are correct?

(A) I, II and IV
(B) I, II and III
(C) II and IV
(D) I and III

2006

21. What is the fundamental assumption when deriving the mathematical model for a first-order liquid level process?

(A) The liquid flow throughout the process is highly compressible.
(B) The outlet flow resistance is assumed to be linear or linearized.
(C) The tank surface area varies non-linearly with liquid height.
(D) The physical density of the process liquid is temperature-dependent.

2012

22. What is the standard unit of the time constant (τ) for a first-order liquid level system defined by A (area) and R (resistance)?

(A) Dimensionless
(B) Meters per second
(C) Ohms
(D) Seconds

NODIA

2011

23. For a gas pressure process behaving as a first-order system, the time constant depends primarily on:

(A) Gas color and its corresponding molecular weight
(B) Tank material and its overall thermal conductivity
(C) Inlet pipe diameter and feed line geometry
(D) Gas volume and the outlet valve flow resistance

2022

24. Identify the correct statement regarding the transfer function of a first-order liquid level system $G(s) = \dfrac{R}{\tau s + 1}$.

(A) The steady-state gain is equal to the outlet resistance R.
(B) The steady-state gain is equal to the time constant τ.
(C) The system exhibits an inherently oscillatory response.
(D) The output responds instantaneously to a step input.

2013

25. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The time constant of a liquid level process increases if the cross-sectional area of the tank is increased.
Reason (R): A larger cross-sectional area requires more fluid accumulation to achieve the same change in liquid head.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2023

26. Consider the following statements regarding gas pressure process modeling:
I. Isothermal conditions are often assumed to simplify the state equation.
II. The capacitance is proportional to the vessel volume.
III. The resistance is linear regardless of valve pressure drop.
IV. Mass balances form the core of the dynamic derivation.
Which of the above statements are correct?
(A) I, II and III
(B) I, II and IV
(C) II, III and IV
(D) I and IV

2007

27. Identify the correct pair representing capacitance (C) in first-order process models.
(A) Liquid level – Cross-sectional area
(B) Liquid level – Tank height
(C) Gas pressure – Outlet valve resistance
(D) Gas pressure – Gas constant (R)

2011

28. Consider the following steps for deriving a first-order model:
I. Formulate unsteady-state mass/energy balance.
II. Formulate steady-state mass/energy balance.
III. Subtract steady-state from unsteady-state to form deviation variables.
IV. Take Laplace transform directly on non-linear terms.
V. Linearize non-linear terms before applying Laplace transform.
Which of the above steps are correct for the derivation?
(A) I, II, III and IV
(B) I, II, III and V
(C) II, III, IV and V
(D) I, III, IV and V

2008

29. Match the physical parameter (List I) to its role in the liquid level time constant $\tau = AR$ (List II).
List I: Physical parameter
P. Tank Area
Q. Valve Resistance
R. Liquid Density
S. Gravity
List II: Role
1. Affects static head
2. Creates flow opposition
3. Provides accumulation capacity
4. Defines potential energy driver
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-4, R-1, S-2
(D) P-3, Q-2, R-1, S-4

NODIA

2023

30. Which condition causes a gas storage process to deviate from a first-order dynamic model?
(A) When the flow through the outlet valve is turbulent and linearized
(B) When the gas volume within the vessel remains constant
(C) When thermal transients cause internal temperature fluctuations
(D) When the inlet pressure to the vessel remains constant

2023

31. The dynamic step-response of a first-order thermal process is mathematically characterized by:
(A) A sinusoidal decay with high-frequency oscillation
(B) An exponential approach to a new steady-state value
(C) A linear ramp function with a constant

positive slope
(D) A parabolic curve increasing quadratically over time

2025
32. Consider the following statements regarding first-order thermal processes:
I. The time constant is defined as $\frac{\text{Mass} \times \text{Heat Capacity}}{\text{UA}}$.
II. A step change in heat input causes an instantaneous jump in temperature.
III. The response reaches 63.2% of its final value at $t = \tau$.
Which of the above statements are INCORRECT?
(A) I and II
(B) II only
(C) I and III
(D) III only

2025
33. In a well-mixed liquid heating tank modeled as a first-order process, the steady-state gain relates the change in steady-state temperature to:
(A) The change in the heat input rate
(B) The change in the tank's physical volume
(C) The change in the specific heat capacity
(D) The derivative of the inlet flow rate

2012
34. What mathematical function defines the temperature deviation response $T'(t)$ of a first-order thermal system to a step change in heat input of magnitude M?
(A) $T'(t) = KM\exp\left(-\frac{t}{\tau}\right)$
(B) $T'(t) = KM\left[1 + \exp\left(-\frac{t}{\tau}\right)\right]$
(C) $T'(t) = KM\left[1 - \exp\left(-\frac{t}{\tau}\right)\right]$
(D) $T'(t) = KM\sin\left(\frac{t}{\tau}\right)$

2024
35. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In a first-order thermal process, increasing the overall heat transfer coefficient (U) decreases the time constant.
Reason (R): A higher heat transfer coefficient increases the thermal resistance of the system.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013
36. Consider the following statements regarding the time constant of a stirred-tank heater:
I. It is directly proportional to the fluid mass.
II. It is inversely proportional to the fluid mass flow rate.
III. It is independent of the fluid's specific heat.
IV. It represents the time to reach 95% of the final steady state.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and IV
(D) III and IV

2022
37. Comparing two first-order thermal processes, Process A has $\tau = 10$ min and Process B has $\tau = 5$ min. Which statement is correct?
(A) Process A reaches steady state faster than Process B.
(B) Process B reaches steady state faster than Process A.
(C) Both processes reach steady state at the exact same time.
(D) Process A has a higher steady-state gain.

2024
38. Which parameter is least relevant to the derivation of the time constant for an internally heated, perfectly mixed, insulated continuous flow tank?
(A) Total fluid mass accumulated inside the heating tank
(B) Specific heat capacity of the process fluid being heated
(C) Ambient air temperature outside the insulated tank wall
(D) Mass flow rate of the process fluid entering the system

2002
39. Match the thermal parameter (List I) with its analogue in electrical circuits (List II).
List I: Thermal parameter
P. Temperature difference
Q. Heat flow rate
R. Thermal mass (mc_p)
S. Thermal resistance ($\frac{1}{UA}$)
List II: Electrical analogue
1. Current

Downloaded from www.pdf.tube

2. Voltage
3. Electrical resistance
4. Capacitance

(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-2, S-1
(C) P-2, Q-3, R-1, S-4
(D) P-2, Q-1, R-4, S-3

2021

40. From the energy balance equation $mc_p\frac{dT}{dt} = wc_p(T_i - T) + Q$, what is the expression for the system time constant (τ)?

(A) $\tau = \frac{m}{w}$

(B) $\tau = \frac{w}{m}$

(C) $\tau = \frac{mc_p}{Q}$

(D) $\tau = \frac{Q}{wc_p}$

2022

41. When two first-order multi-capacity processes interact, the overall transfer function exhibits an equivalent denominator equivalent to an overdamped system. Why?

(A) The interaction introduces dynamic positive feedback, which can cause instability.
(B) The interaction yields distinct real poles, slowing the overall response.
(C) The interaction creates complex conjugate poles in the left-half plane.
(D) The effective system time constants become purely imaginary under load changes.

2005

42. In an interacting second-order liquid level process (two tanks in series with flow between them dependent on both levels), the total effective resistance is:

(A) Less than the sum of the individual valve resistances
(B) Dependent on level differences between the two connected tanks
(C) Exactly equal to the first primary tank's outlet flow resistance
(D) Mathematically irrelevant to the overall steady-state system gain

2007

43. What defines the key structural difference in the transfer function block diagram of an interacting multi-capacity process compared to a non-interacting one?

(A) An internal feedback loop representing the interaction
(B) The addition of a pure dead time block in the forward path
(C) The removal of the steady-state gain blocks in series
(D) The mathematical elimination of the Laplace variable s entirely

NODIA

2007

44. Consider the following statements regarding interacting second-order processes:

I. The roots of the characteristic equation can be complex.
II. The effective time constants are larger than the individual non-interacting time constants.
III. Interaction makes the dynamic response inherently faster.

Which of the above statements are INCORRECT?

(A) I and II
(B) II and III
(C) I and III
(D) I only

2017

45. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): Two interacting tanks in series respond more sluggishly than two identical non-interacting tanks in series.

Reason (R): The level in the second tank exerts back-pressure, hindering the flow from the first tank.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2023

46. For an interacting system with true individual time constants τ_1 and τ_2, the effective time constants τ_1' and τ_2' generated by interaction follow which rule?

(A) $\tau_1' = \tau_1$ and $\tau_2' = \tau_2$
(B) $\frac{\tau_1'}{\tau_2'} = 1$
(C) $\tau_1' > \tau_1$ and $\tau_2' < \tau_2$
(D) $\tau_1' + \tau_2' = \tau_1 + \tau_2$

2002

47. Identify the correct statement regarding the poles of an interacting multi-capacity process model.
(A) They are purely imaginary.
(B) They are real and negative.
(C) They exhibit a damping ratio less than 1.
(D) They lie in the right half of the s-plane.

2006

48. Match the system configuration (List I) with its dynamic term or denominator (List II).
List I: System configuration
P. Single first-order
Q. Two non-interacting
R. Two interacting
S. Pure dead time
List II: Dynamic term or denominator
1. $(\tau_1 s+1)(\tau_2 s+1)$
2. $(\tau_1 s+1)(\tau_2 s+1)+A_1 R_2 s$
3. $\tau s+1$
4. $e^{-\theta s}$
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-3, R-4, S-2
(C) P-2, Q-4, R-1, S-3
(D) P-3, Q-1, R-2, S-4

2013

49. Which of the following provides the best physical example of an interacting multi-capacity process?
(A) Two water tanks connected at their bases by a single open pipe
(B) Two distinct continuous flow stirred tank reactors with a pump between them
(C) A thermocouple placed inside a thermowell
(D) A single pneumatic control valve

2011

50. In terms of response characteristics, interaction in multi-capacity systems leads primarily to:
(A) Significant increase in steady-state process offset
(B) Pronounced decrease in the apparent process dead time
(C) Slower overall transient response under load disturbances
(D) Appearance of high-frequency oscillatory behaviors

2014

51. The transfer function for two non-interacting first-order systems in series is formulated by:
(A) Multiplying their individual transfer functions
(B) Adding their individual transfer functions
(C) Dividing the first transfer function by the second
(D) Squaring the first transfer function

2011

52. Consider the following statements concerning non-interacting multi-capacity processes:
I. The output of the first stage acts as the forcing function for the second stage.
II. The second stage exerts back-pressure on the first stage.
III. The overall transfer function denominator is $(\tau_1 s+1)(\tau_2 s+1)$.
Which of the above statements are correct?
(A) I and III
(B) II and III
(C) I and II
(D) III only

2007

53. An overdamped second-order response ($\zeta > 1$) typically emerges naturally from connecting:
(A) A proportional controller combined with a pure integrating element
(B) Two non-interacting first-order processes connected in series
(C) Two ideal dead-time delay processes connected in parallel paths
(D) A pure derivative controller block paired with a first-order system

2005

54. What is the damping ratio (ζ) for a non-interacting second-order process formed by two tanks with identical time constants ($\tau_1 = \tau_2 = \tau$)?
(A) 0.0
(B) 0.5
(C) 1.0
(D) 1.4

2001

55. Select the correct sequence of events when a step input is applied to a two-tank non-interacting system.
(A) Tank 2 responds instantly → Tank 1 level drops → New steady state
(B) Tank 1 and Tank 2 levels rise synchronously at exactly the same rate
(C) Flow to Tank 2 drops initially → Tank 1 level spikes → System stabilizes
(D) Input step → Tank 1 level rises exponentially → Flow to Tank 2 increases gradually → Tank 2 level follows an S-curve

Click Here to Buy book on Amazon

2008

56. Consider the following response speeds for equivalent time constants:

I. Single first-order system

II. Two non-interacting systems in series

III. Two interacting systems in series

Which of the above represents the correct sequence of response speeds from fastest to slowest?

(A) I, II, III

(B) I, III, II

(C) III, II, I

(D) II, I, III

2017

57. Identify the INCORRECT statement about the step response of a non-interacting multi-capacity process.

(A) The initial slope of the response curve at time zero is exactly zero.

(B) The response exhibits oscillatory overshoot before settling.

(C) The dynamic response curve eventually exhibits a clear inflection point.

(D) The output response closely resembles a sigmoidal or "S" shape curve.

2012

58. For the transfer function $G(s) = \dfrac{1}{(2s+1)(3s+1)}$

What are the poles of the non-interacting system?

(A) -3.0 and -2.0

(B) -0.5 and -0.333

(C) 0.333 and 0.5

(D) 2.0 and 3.0

2009

59. Match the term (List I) with its attribute in a non-interacting series system (List II).

List I: Term

P. Overall Gain

Q. Overall phase lag

R. Initial slope

S. Time constants

List II: Attribute in a non-interacting series system

1. Remains zero at $t = 0$
2. Product of individual gains
3. Sum of individual phase lags
4. Independent of downstream stages

(A) P-2, Q-3, R-1, S-4

(B) P-1, Q-4, R-2, S-3

(C) P-3, Q-1, R-4, S-2

(D) P-2, Q-1, R-3, S-4

2016

60. Consider the following statements regarding the mathematical form of a non-interacting second-order system:

I. $\tau = \sqrt{\tau_1 \tau_2}$

II. $\zeta = \dfrac{\tau_1 + \tau_2}{2\sqrt{\tau_1 \tau_2}}$

III. The damping factor ζ can be less than 1 if properly designed.

Which of the above statements are correct?

(A) I and II

(B) I and III

(C) II and III

(D) I only

2021

61. Rise time in an underdamped second-order system is defined as the time required for the response to:

(A) Remain within a 2% tolerance band of the final steady-state value

(B) Reach its absolute maximum peak value during transient response

(C) Cross fifty percent of the final target steady-state value

(D) Reach the target steady-state value for the first time

2004

62. Which time domain specification measures the maximum deviation of the process variable beyond its final steady-state target?

(A) Settling time

(B) Delay time

(C) Peak overshoot

(D) Rise time

NODIA

2023

63. How is delay time (t_d) defined for a dynamic process evaluation?

(A) Time needed to reach one hundred percent of the final value

(B) Time to reach fifty percent of the final steady-state value

(C) Time the output variable remains at zero before initial movement

(D) Time required for the transient response to decay to 36.8%

2004

64. Identify the correct statement regarding settling time (t_s).

(A) It depends only on the natural frequency of the closed-loop system.

(B) It occurs earlier than the peak transient time in an underdamped system.

(C) It is mathematically independent of the damping ratio of the system.
(D) It is measured using a 2% or 5% tolerance band around the final value.

2007
65. Select the correct sequence of occurrences for an underdamped step response.
(A) Delay time, Peak time, Rise time, Settling time
(B) Delay time, Rise time, Peak time, Settling time
(C) Rise time, Delay time, Peak time, Settling time
(D) Rise time, Peak time, Delay time, Settling time

2025
66. The decay ratio is a specific metric related to overshoot. What does a decay ratio of 1/4 signify?
(A) The steady-state offset error is reduced by exactly twenty-five percent.
(B) The total settling time of the process is divided by a factor of four.
(C) The second peak amplitude is one-fourth of the first peak amplitude.
(D) The rise time is exactly twenty-five percent of the total peak time.

2015
67. If the damping ratio (ζ) of a second-order system is decreased towards zero, what happens to the peak overshoot?
(A) It increases toward 100%.
(B) It decreases exponentially.
(C) It drops to zero.
(D) It remains mathematically unchanged.

2018
68. Consider the following statements concerning the peak time (t_p):
I. It is the time at which the first overshoot maximum occurs.
II. It is given by the formula $t_p = \frac{\pi}{\omega_n \sqrt{1-\zeta^2}}$.
III. It decreases if the natural frequency (ω_n) decreases.
IV. It is defined for underdamped systems ($\zeta < 1$).
Which of the above statements are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I and IV

2017
69. Which parameter is a direct indicator of the relative stability of a dynamic process?
(A) Dead-band width
(B) Peak overshoot
(C) Steady-state gain
(D) Transportation lag

2017
70. What is the approximate 2% settling time formula for a standard second-order system with damping ratio ζ and natural frequency ω_n?
(A) $\frac{1}{\zeta\omega_n}$
(B) $\frac{3}{\zeta\omega_n}$
(C) $\frac{\pi}{\zeta\omega_n}$
(D) $\frac{4}{\zeta\omega_n}$

2018
71. Consider the following steps for constructing a frequency response plot:
I. Determine magnitude and phase angle expressions
II. Substitute $s = j\omega$ into the transfer function $G(s)$
III. Plot magnitude (dB) and phase versus $\log(\omega)$
IV. Rationalize the complex function
Which of the above represents the correct mathematical order of these steps?
(A) II, IV, I, III
(B) I, II, IV, III
(C) II, I, IV, III
(D) IV, II, I, III

2003
72. In a Bode plot, the magnitude is plotted in decibels (dB). What is the mathematical definition used?
(A) $20\log_{10}(\text{Magnitude})$
(B) $10\log_{10}(\text{Magnitude})$
(C) $\ln(\text{Magnitude})$
(D) $10\ln(\text{Magnitude})$

2012
73. Which feature defines the Nyquist stability criterion for a closed-loop system?
(A) The total number of clockwise encirclements of the origin
(B) Encirclements of the critical point (-1, j0) in the complex plane
(C) The intersection of the polar plot with the

Downloaded from www.pdf.tube

positive imaginary axis
(D) The absolute phase margin of the system exceeding 180 degrees

2003

74. Identify the correct statement regarding phase margin.
(A) It is evaluated mathematically at the phase crossover frequency limit.
(B) Phase shift needed at the gain crossover frequency to cause instability.
(C) A negative value of the phase margin indicates absolute closed-loop stability.
(D) It is independent of changes in open-loop system gain.

2012

75. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Adding transportation lag (dead time) to a process reduces its phase margin.
Reason (R): Dead time introduces a linear phase lag $-\omega\theta$, pushing the phase curve down without affecting the magnitude curve.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

76. Consider the following statements regarding Bode plots for a first-order system $G(s) = \frac{1}{\tau s + 1}$:
I. The low-frequency magnitude asymptote is 0 dB.
II. The high-frequency magnitude asymptote has a slope of -20 dB/decade.
III. The maximum phase lag is -90 degrees.
IV. The corner frequency occurs at $\omega = \tau$.
Which of the above statements are correct?
(A) I, II and III
(B) II, III and IV
(C) I, III and IV
(D) I, II and IV

2023

77. The Nyquist plot of a typical open-loop stable first-order system forms what geometric shape?
(A) A full circle centered at the origin
(B) A straight vertical line passing through -1
(C) A parabola in the right half plane
(D) A semicircle in the fourth quadrant

2008

78. Gain margin is mathematically defined as:
(A) The magnitude of the open-loop transfer function evaluated at the gain crossover frequency.
(B) The steady-state gain divided by the natural frequency.
(C) The reciprocal of the open-loop magnitude evaluated at the phase crossover frequency.
(D) The exact frequency where the phase angle reaches -90 degrees.

2002

79. Match the frequency response characteristic (List I) with its definition (List II).
List I: Frequency response characteristic
P. Gain crossover freq
Q. Phase crossover freq
R. Gain Margin
S. Phase Margin
List II: Definition
1. Phase $= -180^{\circ}$
2. Magnitude $= 1$ (0 dB)
3. Safety buffer against phase shift
4. Safety buffer against gain increase
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-3, R-1, S-4

NODIA

2019

80. If a continuous process model exhibits a gain margin of 0.5 (or -6 dB), what is inferred about the closed-loop system?
(A) It is highly stable and robust.
(B) It is critically damped.
(C) It lacks transportation lag.
(D) It is unstable.

2006

81. Consider the following operational phases of an ON-OFF controller cycle:
I. Controlled variable drops below lower set limit
II. Controller outputs maximum signal (ON)
III. Controlled variable exceeds upper set limit
IV. Controller outputs minimum signal (OFF)
Which of the above represents the correct sequence of these phases?
(A) I, II, III, IV
(B) I, III, II, IV
(C) III, I, IV, II
(D) II, IV, I, III

2022
82. The dead-band in an ON-OFF controller is specifically designed to:
(A) Completely eliminate steady-state offset during step load disturbances
(B) Increase the mathematical control degrees of freedom in the system
(C) Prevent chattering and excessive cycling of the final control element
(D) Provide perfect derivative control action under highly dynamic conditions

2010
83. Identify the correct statement regarding cycling in ON-OFF control.
(A) Cycling is an inherent characteristic of ON-OFF control in systems with lag.
(B) Cycling can be eliminated by narrowing the dead-band to zero.
(C) The period of cycling is independent of the process dead time.
(D) Cycling occurs only when external disturbances are present.

2014
84. Which parameter is considered the most limiting disadvantage of standard ON-OFF controllers in industrial applications?
(A) Extreme complexity in the initial calibration and setup of parameters
(B) High mathematical modeling requirements for standard loop implementation
(C) Total inability to control basic multi-capacity thermal systems
(D) Lack of a continuous manipulated variable, causing process oscillations

2007
85. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Widening the dead-band in an ON-OFF controller decreases the frequency of final element cycling.
Reason (R): A wider dead-band requires the controlled variable to deviate further before a control action reversal occurs.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008
86. In a discrete multi-speed controller, the control action is characterized by:
(A) Continuous analog variation of the manipulated variable across the control span
(B) Purely two operating states represented by zero percent and full output
(C) Discrete manipulated variable output levels based on the error magnitude
(D) Immediate elimination of steady-state offset without inducing any cycling

2024
87. A dead-band analysis of a household thermostat reveals an upper trip point of 22°C and a lower trip point of 20°C. What is the differential gap (dead-band)?
(A) 2°C
(B) 20°C
(C) 22°C
(D) 42°C

2003
88. Identify the INCORRECT statement about ON-OFF controllers.
(A) They operate purely in the linear region of the final control element.
(B) They are the simplest and cheapest form of feedback control.
(C) The manipulated variable switches between maximum and minimum limits.
(D) They are widely used in large capacity, slow-responding heating systems.

2011
89. Which of the following parameters directly determines the frequency of cycling in an ON-OFF control system?
(A) The width of the controller dead-band
(B) The derivative time of the controller
(C) The integral reset rate of the loop
(D) The proportional band of the actuator

2017
90. Which physical process is least suited for an ON-OFF controller?
(A) High-capacity hot water storage tank
(B) Fast-reacting high-pressure gas flow
(C) Large-scale industrial refrigeration unit
(D) Standard household electric baking oven

2014
91. In single-speed floating control, the final control element moves:
(A) At constant speed when the error exceeds a neutral zone

Click Here to Buy book on Flipkart

(B) At a speed directly proportional to the error magnitude
(C) Instantaneously from a fully open to a fully closed state
(D) When the calculated error derivative becomes positive

2022

92. The mathematical representation of a single-speed floating controller's output rate ($\frac{dm}{dt}$) outside the neutral zone is:
(A) $\frac{dm}{dt} = K_c E$
(B) $\frac{dm}{dt} = 0$
(C) $\frac{dm}{dt} = \pm K$
(D) $m = K \int E dt$

2016

93. What is the primary purpose of the neutral zone in floating control modes?
(A) To dynamically increase the controller speed of response
(B) To act effectively as a pure derivative control action
(C) To allow the system operator manual override capabilities
(D) To prevent the final control element from hunting over time

2006

94. Identify the correct statement regarding multiple-speed floating control.
(A) It eliminates the need for a neutral operating zone.
(B) It provides a continuous and analog change in actuator valve speed.
(C) It adjusts final element speed in discrete steps based on error thresholds.
(D) It generates high transient overshoot during load changes.

2011

95. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Floating control can eventually eliminate steady-state offset following a sustained load disturbance.
Reason (R): The control element continues to move as long as an error exists, essentially providing an integrating action.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016

96. Which factor directly determines the stability of a single-speed floating control system?
(A) The ambient temperature of the control room
(B) The color-coding of the instrumentation wires
(C) The weight of the measuring sensor
(D) The speed of the final control element

2001

97. Consider the following statements regarding single-speed floating control:
I. The output is a linear function of the error magnitude.
II. It is mathematically equivalent to proportional control.
III. It involves a constant actuator velocity.
Which of the above statements are INCORRECT?
(A) I and II
(B) II and III
(C) I and III
(D) III only

2021

98. Match the floating control terminology (List I) with its definition (List II).
List I: Floating control terminology
P. Neutral Zone
Q. Actuator Speed
R. Actuator Position
S. Multiple-speed
List II: Definition
1. Integral of the constant rate
2. Region of zero control action
3. Constant value $\pm K$
4. Stepped velocity profile
(A) P-1, Q-4, R-3, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-2, Q-3, R-1, S-4
(D) P-2, Q-4, R-1, S-3

2013

99. Floating control is most frequently implemented using which type of physical actuator?
(A) Slow-moving reversible electric motors
(B) Fast-acting pneumatic cylinders
(C) Instantaneous solenoid valves
(D) Manual handwheel override mechanisms

Downloaded from www.pdf.tube

2021

100. How does the dynamic response of a floating controller compare to a standard Proportional (P) controller?
(A) Floating control exhibits less phase lag than proportional control.
(B) Floating control is faster than proportional control under typical process disturbances.
(C) Floating control is ineffective for standard liquid level loops.
(D) Floating control integrates the error to eliminate offset, unlike proportional control.

2002

101. The mathematical equation for an ideal Proportional (P) controller is:
(A) $p(t) = K_c \int e(t)dt$
(B) $p(t) = K_c e(t) + p_s$
(C) $p(t) = K_c \frac{de(t)}{dt}$
(D) $p(t) = K_c e(t) \cdot p_s$

2015

102. What is the fundamental relationship between Proportional Band (PB) and Controller Gain (K_c)?
(A) $PB = K_c \times 100$
(B) $PB = \ln(K_c)$
(C) $PB = \frac{100}{K_c}$
(D) $PB = K_c^2$

2008

103. Steady-state offset is an inherent characteristic of pure Proportional control. It is defined as:
(A) The time delay occurring between initial error detection and valve movement
(B) The absolute value of the initial peak overshoot dynamic magnitude
(C) The physical distance measured between the sensor and the controller
(D) The permanent residual error remaining after a process load change

2023

104. Identify the correct statement regarding proportional band (PB).
(A) A 100% proportional band means the controller gain is 1.0.
(B) A narrow proportional band implies low controller gain and sluggish loop response.
(C) Increasing the proportional band increases the oscillatory process behavior.
(D) A proportional band of zero percent provides a linear process control loop.

2018

105. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Increasing the proportional gain (K_c) decreases the steady-state offset.
Reason (R): A higher gain produces a larger corrective output for the same error, requiring a smaller residual error to sustain the new load.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

106. The offset mechanism in a proportional-only liquid level control system is mathematically caused by:
(A) The mathematical accumulation and integration of noise in the level transmitter
(B) The need for a sustained error to maintain the adjusted manipulated variable
(C) The inherent non-linear square root characteristic of the outlet valve
(D) The mechanical or electrical failure of the final physical control element

2001

107. Which pair correctly identifies the effect of altering K_c on the proportional control response?
(A) Increased K_c – Increased system oscillation
(B) Increased K_c – Increased permanent steady-state offset
(C) Decreased K_c – Decreased percentage proportional band
(D) Decreased K_c – Faster initial response to input step change

2004

108. Consider the following statements concerning P-control dynamics:
I. It responds instantaneously to current error.
II. It cannot anticipate future errors.
III. It guarantees zero steady-state error for step disturbances.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2013

109. Match the P-controller term (List I) with its practical meaning (List II).

NODIA

List I: P-controller term
P. Bias (p_s)
Q. Error (e)
R. Gain (K_c)
S. Output (p)
List II: Practical meaning
1. Difference between setpoint and variable
2. Sensitivity of control action
3. Controller signal to valve
4. Base output when error is zero
(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-2, R-1, S-3
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-1, R-2, S-3

2024
110. If a controller has a proportional band of 25%, what is the corresponding controller gain (K_c)?
(A) 0.25
(B) 2.5
(C) 4.0
(D) 25.0

2024
111. Integral control action (reset) is added to a proportional controller primarily to:
(A) Speed up the initial transient response
(B) Eliminate the steady-state offset
(C) Provide predictive action against sudden disturbances
(D) Decrease the overall system order

2011
112. The mathematical mechanism by which integral action eliminates offset involves:
(A) Outputing a control signal proportional to the rate of error change
(B) Ignoring very small process errors entirely within a specified dead-band
(C) Resetting the system setpoint to match the current measured variable
(D) Changing the controller output as long as a non-zero error exists

2019
113. Derivative (rate) control action improves the dynamic response by:
(A) Anticipating future errors based on the rate of error change
(B) Integrating the accumulated error over a very long time horizon
(C) Increasing the final steady-state offset value in the system
(D) Acting as a high-performance low-pass filter to remove noise

2008
114. Identify the correct statement regarding derivative control action.
(A) It responds exceptionally strongly to constant, steady-state process errors.
(B) It inherently decreases the dynamic stability of physical process loops.
(C) It cannot be used alone as it has no output when error is constant.
(D) It is immune to high-frequency process measurement noise.

2023
115. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Derivative control is highly sensitive to high-frequency measurement noise.
Reason (R): Derivative control increases the low-frequency steady-state gain of the closed-loop system.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2022
116. Consider the following statements concerning integral and derivative control:
I. Integral action decreases relative stability (increases phase lag).
II. Derivative action adds phase lead, improving stability margins.
III. Reset time (T_i) is inversely proportional to the integral control effect.
IV. Derivative action amplifies high-frequency measurement noise.
Which of the above statements are correct?
(A) I, II, III and IV
(B) I, II and III
(C) II, III and IV
(D) I and IV

2003
117. Which parameter dictates the strength of the integral action in a standard PID formulation?
(A) Derivative time (T_d)
(B) Integral time (T_i) or reset rate
(C) The process steady-state gain (K_p)
(D) The amplitude of the disturbance

Click Here to Buy book on Amazon

2024

118. In industrial terminology, the "reset rate" (repeats per minute) is mathematically related to integral time (T_i) as:

(A) $T_i \times 60$

(B) T_i^2

(C) $\frac{1}{T_i}$

(D) $\ln(T_i)$

2006

119. Match the control mode (List I) with its characteristic operational effect (List II).

List I: Control mode

P. Proportional

Q. Integral

R. Derivative

S. ON-OFF

List II: Characteristic operational effect

1. Eliminates offset
2. Anticipates error
3. Provides base response with offset
4. Induces continuous cycling

(A) P-1, Q-2, R-3, S-4

(B) P-3, Q-2, R-1, S-4

(C) P-2, Q-4, R-1, S-3

(D) P-3, Q-1, R-2, S-4

2024

120. A phenomenon called "derivative kick" occurs when:

(A) The derivative action is applied directly to a setpoint step change.

(B) The selected integral time of the loop is set to an exceptionally low value.

(C) The composite controller output quickly reaches its physical saturation limit.

(D) The proportional band is widened significantly during process optimization.

2010

121. The ideal dynamic equation for a composite Proportional-Integral-Derivative (PID) controller is:

(A) $p(t) = K_c \cdot e(t) \cdot \tau_I \int e(t)\,dt \cdot \tau_D \frac{de(t)}{dt}$

(B) $p(t) = K_c\left[e(t) + \frac{1}{\tau_I}\int e(t)\,dt + \tau_D \frac{de(t)}{dt}\right]$

(C) $p(t) = K_c\left[e(t) + \tau_I \int e(t)\,dt + \frac{1}{\tau_D}\frac{de(t)}{dt}\right]$

(D) $p(t) = K_c + e(t) + \tau_I + \tau_D$

2019

122. A P+I controller (Proportional-Integral) is most suitable for application in:

(A) Systems where derivative action is required to counteract extremely large dead times.

(B) Fast-responding loops where steady-state offset must be eliminated and noise makes derivative action undesirable.

(C) Slow systems where offset is acceptable and high-frequency noise is absent.

(D) Loops that can be controlled adequately using simple ON-OFF controllers without any lag.

2003

123. The transfer function of an ideal PID controller is given by:

(A) $G_c(s) = K_c\left(1 + \frac{1}{\tau_I s} + \tau_D s\right)$

(B) $G_c(s) = K_c(1 + \tau_I s + \tau_D s)$

(C) $G_c(s) = K_c\left(\frac{1}{\tau_I s \cdot \tau_D s}\right)$

(D) $G_c(s) = K_c\left(\tau_I s + \frac{1}{\tau_D s}\right)$

2021

124. Consider the following statements about P+D controllers:

I. They eliminate steady-state offset.

II. They provide a stabilizing effect by adding phase lead.

III. They are unsuitable for loops with high-frequency noise.

Which of the above statements are correct?

(A) I and II

(B) II and III

(C) I and III

(D) III only

2002

125. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): In practice, the derivative term in a PID controller is often accompanied by a first-order lag filter.

Reason (R): Pure derivative action would amplify high-frequency measurement noise to unacceptable levels.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

NODIA

2010

126. Which composite controller architecture is universally referred to as a "three-mode" controller?
(A) Proportional-Integral controller
(B) Cascade-Feedforward system
(C) Proportional-Integral-Derivative
(D) Multi-speed floating action

2017

127. Identify the correct pair matching the process type to the recommended composite controller.
(A) Liquid Flow loop – P+D control
(B) Temperature loop – PID control
(C) Level loop with noise – Pure Derivative control
(D) Gas Pressure loop – Multi-speed ON-OFF

2021

128. What is the phenomenon of "integral windup" in composite controllers?
(A) The derivative term oscillating uncontrollably in the high-frequency range.
(B) The mechanical or electrical breakdown of the internal controller springs.
(C) The sudden change in the setpoint causing a huge spike in controller output.
(D) Accumulation of integral term during actuator saturation, delaying recovery.

2009

129. Match the composite architecture (List I) with its dominant frequency response trait (List II).
List I: Composite architecture
P. P-only
Q. PI
R. PD
S. PID
List II: Dominant frequency response trait
1. Adds phase lead
2. Adds phase lag at low frequencies
3. Constant phase angle of 0° for all freq (ideal)
4. High LF gain and HF phase lead
(A) P-3, Q-2, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-4, R-1, S-2

2010

130. Why is PID control often preferred over PI control for batch reactor temperature regulation?
(A) It simplifies the mathematical analysis of complex chemical reactions.
(B) PI control cannot effectively handle processes with non-linear heat capacities.
(C) The derivative action counters thermal inertia and minimizes overshoot.
(D) PID automatically adjusts its own integral and derivative time parameters.

2011

131. The Integral of Absolute Error (IAE) criterion is mathematically formulated as:
(A) $\int \mid e(t) \mid dt$
(B) $\int e^2(t)dt$
(C) $\int t \cdot \mid e(t) \mid dt$
(D) $\int t \cdot e^2(t)dt$

2008

132. Which error-based criterion heavily penalizes large initial transient errors while being less sensitive to small residual errors?
(A) IAE
(B) ITAE (Integral of Time-weighted Absolute Error)
(C) Mean Absolute Deviation
(D) ISE (Integral of Squared Error)

2017

133. The ITAE criterion ($\int t \mid e(t) \mid dt$) is particularly effective for controller tuning because it explicitly penalizes:
(A) Large initial transient step errors
(B) Errors persisting over long duration
(C) High-frequency measurement noise components
(D) The derivative of the transient error

2018

134. Identify the correct statement comparing ISE and ITAE performance criteria.
(A) ISE results in a highly oscillatory response with long settling times, while ITAE promotes heavily damped responses.
(B) ISE yields conservative, slow responses, while ITAE focuses primarily on rise time.
(C) ITAE typically produces a tuning that minimizes long-duration tails in the response curve better than ISE.
(D) They are mathematically identical for first-order systems.

2003

135. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The Integral of Time-weighted Absolute Error (ITAE) is the most widely favored criterion for optimal PID tuning.

Downloaded from www.pdf.tube

Reason (R): It balances the penalty on initial deviations and persistent long-term errors, yielding responses with minimal oscillation and short settling times.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025

136. Which formula defines the Integral of Squared Error (ISE)?

(A) $\int_0^\infty e(t)\,dt$

(B) $\int_0^\infty te^2(t)\,dt$

(C) $\int_0^\infty e^2(t)\,dt$

(D) $\int_0^\infty t^2 e^2(t)\,dt$

2009

137. An application requires rapid elimination of very large, sudden load disturbances without concern for minor subsequent oscillations. Which criterion tuning is most appropriate?

(A) IAE
(B) ITAE
(C) ITSE
(D) ISE

2004

138. Consider the following statements regarding error criteria in control systems:

I. IAE accumulates all errors equally regardless of time or magnitude square.
II. ISE squares the error, heavily penalizing small errors over large ones.
III. ITAE multiplies the error by time, heavily penalizing long-lasting errors.

Which of the above statements is/are INCORRECT?

(A) I and III
(B) II only
(C) III only
(D) I and II

2013

139. Match the tuning objective in List I with the most appropriate error criterion in List II:

List I: Tuning Objective
P. Suppress large initial errors
Q. Penalize long-duration oscillations
R. Balanced general suppression
S. Absolute integral zeroing

List II: Error Criterion
1. ITAE
2. ISE
3. IAE
4. Direct algebraic sum of error

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-3, R-1, S-4

2022

140. Which specific performance characteristic is generally minimized when a controller is tuned using the IAE criterion?

(A) Peak overshoot percentage of the response
(B) Total absolute area under the error curve
(C) Natural frequency of the closed-loop system
(D) Steady-state amplitude of the input step

NODIA

2009

141. The Process Reaction Curve (Cohen-Coon method) is an open-loop tuning technique. It mathematically models the process as a:

(A) First-order system plus dead time
(B) Second-order system with zero delay
(C) Purely integrating process system
(D) Third-order interacting system

2025

142. To extract the FOPDT parameters for Cohen-Coon tuning, the operator must:

(A) Switch the controller to automatic mode and induce sustained oscillations
(B) Step-change the setpoint in automatic mode to observe derivative kick
(C) Apply an open-loop step test in manual mode and record the response
(D) Disconnect the final control element and log the valve position drift

2017

143. Which three parameters are extracted from the open-loop step response curve in the Cohen-Coon method?

(A) Ultimate gain (K_u), Ultimate period (P_u), Amplitude ratio
(B) Peak overshoot, Settling time, Rise time
(C) Natural frequency, Damping ratio, Phase margin
(D) Process gain (K_p), Dead time (θ), Time constant (τ)

2025

144. Identify the correct statement regarding the limitations of the Cohen-Coon open-loop tuning method.
(A) It is highly effective for systems with zero dead time.
(B) It requires driving the closed-loop system to instability.
(C) It is sensitive to load disturbances during the test.
(D) It works best for purely integrating process systems.

2012

145. Given the following assertion and reason, select the correct option:
Assertion (A): The Cohen-Coon method provides better tuning parameters than simple Ziegler-Nichols for processes with a large dead-time-to-time-constant ratio ($\frac{\theta}{\tau}$).
Reason (R): Cohen-Coon tuning equations explicitly account for the ratio of dead time to time constant across a wider range.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

146. In determining the process parameters from the reaction curve, the apparent dead time (θ) is estimated by:
(A) The time required to reach 63.2% of the final output response
(B) The total time required for the system output to settle completely
(C) The mathematical inverse of the steady-state process gain value
(D) The time from the step input to the tangent-baseline intersection

2014

147. What is the fundamental formula for the process gain (K_p) extracted from a process reaction curve?
(A) $K_p = \dfrac{\text{Change in Process Variable}}{\text{Change in Controller Output}}$
(B) $K_p = \dfrac{\text{Time Constant}}{\text{Dead Time}}$
(C) $K_p = \text{Maximum Slope of the Tangent}$
(D) $K_p = \dfrac{\text{Change in Controller Output}}{\text{Change in Process Variable}}$

2012

148. Consider the following statements regarding the Cohen-Coon method:
I. It is an open-loop test.
II. It requires continuous process cycling to find parameters.
III. It models the system as $\dfrac{K_p e^{-\theta s}}{\tau s + 1}$.
Which of the above statements is/are INCORRECT?
(A) I and III
(B) II only
(C) I and II
(D) III only

2003

149. Match the parameter in List I with its extraction method from the reaction curve in List II:
List I: Parameter
P. Process Gain
Q. Dead Time
R. Time Constant
S. Tangent Line
List II: Extraction Method
1. Drawn at inflection point
2. Time from step to tangent baseline intersection
3. Final steady state change divided by input step
4. Time from baseline intersection to 63.2% of final value (or tangent intersection at final value)
(A) P-3, Q-2, R-4, S-1
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-3, R-4, S-1

2023

150. A major advantage of using open-loop process reaction curve tuning in an industrial setting is:
(A) It requires driving the control system to its stability limit.
(B) It does not require bringing the system to the verge of instability.
(C) It can be performed while the process is under fully automatic cascade control.
(D) It maintains stability and causes less process disruption.

2004

151. The Ziegler-Nichols ultimate-cycle method requires placing the PID controller in:
(A) Manual mode with only proportional control action enabled

Click Here to Buy book on Flipkart

(B) Automatic mode with only proportional control action active
(C) Automatic mode with only integral control action active
(D) Cascaded open-loop mode with all feedback actions disabled

2017

152. In the Ziegler-Nichols ultimate-cycle method, the "ultimate gain" (K_u) is defined as the controller gain that produces:
(A) The fastest possible decay ratio
(B) A critically damped response
(C) Sustained, constant-amplitude oscillations
(D) Minimum steady-state offset without oscillation

2012

153. What is the "ultimate period" (P_u) in the Ziegler-Nichols closed-loop tuning method?
(A) The time taken for the system to reach its first peak
(B) The total time required to eliminate steady-state offset
(C) The time delay period representing process dead time
(D) The period of sustained oscillations at ultimate gain

2022

154. According to Ziegler-Nichols tuning rules for a P-only controller, the recommended controller gain K_c is mathematically set to:
(A) $0.45K_u$
(B) $0.5K_u$
(C) $0.6K_u$
(D) $1.0K_u$

2003

155. Select the correct formula sequence for tuning a PID controller using the Ziegler-Nichols ultimate cycle method.
(A) $K_c = 0.45K_u,\ T_i = \frac{P_u}{1.2},\ T_d = \frac{P_u}{8}$
(B) $K_c = 0.6K_u,\ T_i = 0.5P_u,\ T_d = 0.125P_u$
(C) $K_c = K_u,\ T_i = P_u,\ T_d = P_u$
(D) $K_c = 0.5K_u,\ T_i = 0.125P_u,\ T_d = 0.5P_u$

2004

156. The damped oscillation method (often a modification of Ziegler-Nichols) targets a specific response characteristic. What decay ratio is typically targeted by classic Ziegler-Nichols tuning parameters?
(A) $\frac{1}{10}$ (tenth-wave decay)
(B) $\frac{1}{4}$ (quarter-wave decay)
(C) $\frac{1}{2}$ (half-wave decay)
(D) $\frac{1}{1}$ (zero amplitude decay)

2011

157. Identify the INCORRECT statement regarding the Ziegler-Nichols closed-loop method.
(A) It is highly suitable for open-loop unstable processes.
(B) It requires driving the plant to the verge of instability.
(C) It is primarily empirical and based on the ultimate gain and period.
(D) It may be unsafe for sensitive or hazardous chemical reactions.

NODIA

2023

158. If a process yields an ultimate gain of $K_u = 10$ and ultimate period of $P_u = 4$ seconds, what is the Ziegler-Nichols recommended integral time (T_i) for a PI controller?
(A) 0.5 seconds
(B) 1.2 seconds
(C) 2.0 seconds
(D) 3.33 seconds

2017

159. Match the Ziegler-Nichols control architecture in List I with its proportional gain setting (K_c) rule in List II:
List I: Control Architecture
P. Proportional (P)
Q. Proportional-Integral (PI)
R. Proportional-Integral-Derivative (PID)
S. Ultimate Gain State
List II: Proportional Gain Setting Rule
1. $0.6K_u$
2. $0.5K_u$
3. $0.45K_u$
4. $1.0K_u$
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-2, S-4
(C) P-2, Q-1, R-3, S-4
(D) P-2, Q-3, R-1, S-4

2008

160. Given the following assertion and reason, select the correct option:
Assertion (A): The Ziegler-Nichols ultimate cycle method cannot be applied to first-order systems without dead time.
Reason (R): A first-order system without dead

time cannot be driven to sustained oscillation using proportional control alone, as its maximum phase lag is only 90 degrees.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002

161. A Lead compensator is mathematically designed primarily to:
(A) Increase low-frequency gain without affecting high frequencies
(B) Provide positive phase shift to improve the phase margin
(C) Act as a pure integrator to eliminate steady-state offset
(D) Attenuate high-frequency noise across all operations

2023

162. The standard transfer function form of a lead or lag compensator is $G_c(s) = \frac{1+\alpha\tau s}{1+\tau s}$.
For a Lead compensator, the parameter α must be:
(A) $\alpha = 0$
(B) $0 < \alpha < 1$
(C) $\alpha = 1$
(D) $\alpha > 1$

2002

163. In the frequency domain, a Lag compensator provides a characteristic response that:
(A) Attenuates high-frequency gain and introduces phase lag
(B) Shift the system open-loop phase curve directly upward
(C) Acts identically to a proportional-derivative control action
(D) Increases the closed-loop system bandwidth significantly

2021

164. Identify the correct statement regarding Lead and Lag compensator design methodology.
(A) A Lead compensator is typically designed to improve steady-state accuracy.
(B) A Lag compensator is typically designed to improve transient response speed.
(C) A Lead compensator acts like a high-pass filter, improving transient response.
(D) Both compensators are primarily used to increase steady-state offset.

2008

165. Given the following assertion and reason, select the correct option:
Assertion (A): A Lag-Lead compensator combines the benefits of both high low-frequency gain and adequate high-frequency phase margin.
Reason (R): It utilizes the lag portion to improve steady-state error and the lead portion to stabilize the transient response.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

166. Consider the following statements regarding Lead compensators:
I. They introduce a zero that is closer to the origin than their pole.
II. They decrease the overall bandwidth of the system.
III. The maximum phase lead occurs at the geometric mean of the pole and zero frequencies.
Which of the above statements is/are INCORRECT?
(A) I and III
(B) II only
(C) I and II
(D) III only

2007

167. For a lag compensator transfer function $G(s) = \frac{s+z}{s+p}$
The relationship between the pole (p) and zero (z) locations on the real axis is:
(A) The pole is to the right of the zero (closer to the origin).
(B) The zero is to the right of the pole (closer to the origin).
(C) The pole and zero are at the exact same location.
(D) Both are placed in the right half of the s-plane.

2008

168. Match the compensator in List I with its primary design function in List II:
List I: Compensator
P. Lead Compensator
Q. Lag Compensator
R. Lag-Lead

NODIA

S. Proportional Amplifier

List II: Primary Design Function

1. Improve steady state without degrading stability much
2. Improve transient speed and stability
3. Scale gain evenly
4. Optimize both steady state and transient

(A) P-1, Q-2, R-3, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-2, Q-1, R-4, S-3
(D) P-2, Q-3, R-4, S-1

2016

169. What is the frequency characteristic formula for the maximum phase lead angle (ϕ_m) provided by a lead compensator with parameter α?

(A) $\cos(\phi_m) = \frac{\alpha - 1}{\alpha + 1}$
(B) $\tan(\phi_m) = \alpha$
(C) $\sin(\phi_m) = \frac{1}{\alpha}$
(D) $\sin(\phi_m) = \frac{\alpha - 1}{\alpha + 1}$

2021

170. Which hardware component in an analog electronic controller is most commonly adjusted to physically tune a lead-lag compensator?

(A) Resistor-Capacitor (RC) network values
(B) Pneumatic flapper-nozzle distances
(C) Inductor core sizes
(D) Spring tension in the valve actuator

2011

171. The characteristic equation of a closed-loop control system is derived by equating the denominator of the closed-loop transfer function to zero. What is its standard mathematical form?

(A) $G(s) - H(s) = 0$
(B) $1 + G(s)H(s) = 0$
(C) $1 - G(s)H(s) = 0$
(D) $\frac{G(s)}{H(s)} = 1$

2007

172. The Routh-Hurwitz criterion determines system stability strictly by evaluating the roots of the characteristic equation. A system is strictly stable if and only if:

(A) All roots have positive real parts.
(B) All roots have negative real parts.
(C) All roots are strictly imaginary.
(D) At least one root has a negative real part.

2018

173. When constructing a Routh array, what indicates the number of roots lying in the right-half of the s-plane (unstable roots)?

(A) The number of sign changes in the first column
(B) The total number of zero entries in the entire array
(C) The mathematical sum of all elements in the first row
(D) The absolute value of the lowest right-hand element

2010

174. Identify the correct statement regarding a row of all zeros in the Routh array.

(A) It proves that the closed-loop system is absolutely stable.`
(B) It means the characteristic equation was derived incorrectly.`
(C) It indicates the presence of symmetrically located roots.`
(D) It implies all roots of the system are real and unequal.`

2025

175. Given the following assertion and reason, select the correct option:

Assertion (A): The Routh-Hurwitz criterion can directly compute the exact numerical values of complex roots in high-order systems.

Reason (R): It is an algebraic method that relies solely on the coefficients of the characteristic polynomial without solving for the roots.

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2023

176. Consider the following statements regarding the Routh-Hurwitz test:

I. It is an algebraic stability criterion.
II. A necessary (but not sufficient) condition for stability is that all coefficients of the characteristic equation be positive.
III. It can perfectly handle systems with pure dead time ($e^{-\theta s}$) without any mathematical approximation.

Which of the above statements is/are correct?

(A) I and II
(B) I and III
(C) II and III

Downloaded from www.pdf.tube

(D) I only

2012

177. If the characteristic equation is $s^3 + 6s^2 + 11s + 6 = 0$, what is the first element in the third row (s^1 row) of the Routh array?
(A) -6
(B) 6
(C) 10
(D) 11

2001

178. What mathematical technique must be applied to incorporate transportation lag ($e^{-\theta s}$) into a polynomial form suitable for Routh-Hurwitz analysis?
(A) Bode plot mapping
(B) Nyquist mapping
(C) Direct logarithmic expansion
(D) Padé approximation

2003

179. Match the Routh array condition in List I with its stability implication in List II:
List I: Routh Array Condition
P. No sign changes in 1st col
Q. Two sign changes in 1st col
R. Row of zeros evaluated
S. Negative coefficient in poly
List II: Stability Implication
1. Unstable (at least 1 root)
2. Marginally stable possible
3. Strictly stable
4. Two unstable roots
(A) P-3, Q-4, R-2, S-1
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-4, Q-3, R-1, S-2

2021

180. Consider the characteristic equation $s^2 + Ks + 4 = 0$. For what range of K is the system strictly stable?
(A) $K = 0$
(B) $K < 0$
(C) $K > 0$
(D) Any real value of K

2018

181. In Multiple-Input Multiple-Output (MIMO) systems, variable interaction occurs because:
(A) A single manipulated variable structurally affects more than one controlled variable.
(B) There is only one manipulated variable available for multiple controlled variables.
(C) The closed-loop process is fundamentally unstable under open-loop conditions.
(D) Distillation columns and chemical reactors possess no internal process dynamics.

2001

182. The Relative Gain Array (RGA) is a mathematical tool used in MIMO control to:
(A) Tune multiple PID controller parameters automatically in real-time
(B) Calculate the exact steady-state offset under closed-loop control
(C) Convert a MIMO system into a single equivalent open-loop equation
(D) Pair manipulated and controlled variables to minimize interaction

2014

183. In an RGA matrix Λ, the sum of elements in any given row or column always exactly equals:
(A) 0
(B) 1
(C) The condition number of the plant
(D) The determinant of the gain matrix

2025

184. Identify the correct statement regarding variable pairing based on the Relative Gain Array element λ_{ij}.
(A) Pair variables where $\lambda_{ij} = 0$
(B) Pair variables where λ_{ij} is a large negative number
(C) Pair variables where λ_{ij} is close to 1.0
(D) Pair variables where λ_{ij} is exactly 0.5

NODIA

2015

185. Given the following assertion and reason, select the correct option:
Assertion (A): In a standard binary distillation column, adjusting the reflux rate significantly alters both the top product purity and the bottom product purity.
Reason (R): The reflux rate directly changes the internal liquid-vapor traffic throughout the entire length of the interacting MIMO column.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021

186. If a relative gain element λ_{11} is 0.5, what does this mathematically signify about the interaction between the loops?
(A) Severe interaction; loop 1 gain doubles when

loop 2 closes
(B) Zero interaction occurs between the two control loops
(C) The control loop becomes fundamentally unstable under feedback
(D) The control loops are completely decoupled from each other

2008
187. Which component is specifically implemented in advanced control systems to mathematically cancel out MIMO interaction?
(A) Dead-band filter
(B) Decoupler
(C) Derivative lag network
(D) Split-range valve

2008
188. Consider the following statements regarding the Relative Gain Array (RGA):
I. RGA requires a dynamic transfer function matrix to be computed.
II. RGA is scaling-independent (immune to unit changes).
III. RGA elements can be negative.
Which of the above statements is/are INCORRECT?
(A) I only
(B) II only
(C) III only
(D) I and II

2017
189. Match the RGA value in List I with its pairing recommendation in List II:
List I: RGA Value (λ)
P. $\lambda = 1$
Q. $\lambda = 0$
R. $\lambda = 0.5$
S. $\lambda < 0$
List II: Pairing Recommendation
1. Severe interaction, avoid pairing
2. Unstable interaction, never pair
3. Perfect pairing, no interaction
4. No direct effect, do not pair
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-3, R-1, S-4

2018
190. In a heat exchanger MIMO model controlling both outlet temperature and flow rate, adjusting the steam valve position acts as a:
(A) Controlled variable representing a key process setpoint
(B) Strict disturbance variable with zero control authority
(C) Manipulated variable that affects the outlet temperature and interacts with other loops
(D) Fixed parameter that remains constant during operations

2023
191. Feed-forward control architecture is designed fundamentally to:
(A) Measure the final process output and feedback the errors
(B) Cascade multiple process output variables together directly
(C) Eliminate the need for any mathematical process models
(D) Measure disturbances and take preemptive corrective action

2007
192. Which of the following is a strict requirement for the successful implementation of a purely feed-forward control scheme?
(A) The primary process disturbance is unmeasurable.
(B) The controlled process must exhibit zero mathematical dead time.
(C) Accurate models of process and disturbance dynamics must be known.
(D) The physical control system must utilize simple ON-OFF logic.

2016
193. Ratio control is considered a specialized variant of which control architecture?
(A) Cascade control
(B) Feed-forward control
(C) Adaptive control
(D) Split-range control

2025
194. Identify the correct statement regarding Ratio control applications.
(A) It is primarily used to control boiler temperature in steam systems.
(B) It eliminates the need for measuring flow rates of the streams.
(C) The ratio setting cannot be adjusted once the system is online.
(D) It maintains a stoichiometric ratio of reactants entering a reactor.

2012
195. Given the following assertion and reason, select the correct option:

Click Here to Buy book on Amazon

Assertion (A): Feed-forward control is rarely used entirely on its own without a feedback trim loop.
Reason (R): Pure feed-forward control cannot correct for unmeasured disturbances or inaccuracies in the predictive mathematical model.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021

196. In a Feed-forward controller design, the ideal feed-forward transfer function $G_{\{ff\}}$ is mathematically derived as:
(A) $G_{ff} = G_{load} \times G_{process}$
(B) $G_{\{ff\}} = G_{\{load\}} + G_{\{process\}}$
(C) $G_{ff} = -\dfrac{G_{load}}{G_{process}}$
(D) $G_{ff} = \dfrac{1}{G_{process}}$

2009

197. Which industrial application perfectly illustrates Ratio control?
(A) Blending two separate fuel streams in a fixed proportion
(B) Maintaining liquid tank level by adjusting outlet pump speed
(C) Controlling distillation column pressure by venting process gas
(D) Regulating steam valve position based on ambient room temperature

2023

198. Consider the following statements concerning Feed-forward control:
I. It improves rejection of specific measured disturbances.
II. It increases the overall stability margin of the feedback loop mathematically.
III. It does not introduce instability to the closed-loop characteristic equation.
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I only

2003

199. Match the control scheme in List I with its defining trait in List II:
List I: Control Scheme
P. Feedback
Q. Feed-forward
R. Ratio
S. Cascade
List II: Defining Trait
1. Acts on measured error
2. Acts on measured disturbance
3. Maintains variable proportionality
4. Nested controller architecture
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-1, Q-3, R-2, S-4

2005

200. What happens in a Ratio control loop if the 'wild' (uncontrolled primary) flow suddenly drops by 50%?
(A) The controlled secondary flow remains completely constant.
(B) The system issues an alarm and shuts down the secondary pump.
(C) The controller drops the secondary flow by 50% to maintain the ratio.
(D) The wild primary flow is boosted back to 100% by the controller.

2023

201. Cascade control architecture requires a minimum of:
(A) One single controller operating two separate final control elements
(B) Two entirely independent feedback loops operating with separate valves
(C) One process measurement sensor operating two cascaded control valves
(D) Two nested controllers, two sensors, and one final control element

NODIA

2010

202. In a Cascade control system, the output of the master (outer) controller serves strictly as the:
(A) Setpoint for the slave (inner) controller
(B) Final manipulation signal to the valve
(C) Measured disturbance variable
(D) Feedback signal to the primary sensor

2015

203. Inner/outer loop synchronization in Cascade control generally requires the inner (slave) loop to be:
(A) Mathematically identical in speed to the outer loop
(B) Significantly faster dynamically than the

in service
(D) Higher instrument air pressure supplied to the actuator

2024
253. A linear inherent valve characteristic is most highly recommended for control systems where:
(A) The valve pressure drop remains relatively constant across all flow rates
(B) The valve pressure drop is a very small fraction of the total system drop
(C) The fluid temperature is constantly fluctuating near boiling point
(D) The final controller is an ON-OFF type

2010
254. Identify the INCORRECT statement regarding the C_v coefficient.
(A) It is the universal standard for liquid valve capacity.
(B) It requires modification using expansion factors when sizing for compressible gases.
(C) A higher C_v indicates a more restrictive, smaller valve.
(D) The equation is $Q = C_v\sqrt{\frac{\Delta P}{G_f}}$ for liquids.

2011
255. Given the following assertion and reason, select the correct option:
Assertion (A): Sizing a control valve perfectly to the exact maximum anticipated flow rate is poor engineering practice.
Reason (R): It leaves no control margin; standard practice sizes the valve so maximum anticipated flow occurs at 70-80% of total travel.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024
256. When a liquid flashes inside a control valve, the volumetric flow rate exiting the valve:
(A) Remains constant under all operating pressures
(B) Drops to zero in the flow line
(C) Increases significantly due to vapor expansion
(D) Is unaffected by the vapor phase flow

2017
257. Which specific physical property of a fluid directly dictates its vulnerability to flashing and cavitation at a given temperature?
(A) Specific heat capacity
(B) Vapor pressure
(C) Dynamic viscosity
(D) Thermal conductivity

2015
258. Consider the following statements for multi-stage valve trims:
I. They are designed to prevent cavitation.
II. They ensure the pressure at each stage remains above the vapor pressure.
III. They increase the overall noise generated by the valve.
Which of the above statements is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2013
259. Match the physical phenomenon in List I with the recommended valve design countermeasure in List II:
List I: Physical Phenomenon
P. High Pressure Drop Liquids
Q. Flashing
R. High Noise Gas Flow
S. Sticky/Viscous Fluids
List II: Recommended Valve Design Countermeasure
1. Anti-cavitation trim
2. Hardened trim materials & swept-angle body
3. Multi-hole aerodynamic trim
4. Eccentric rotary or ball valves
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-1, Q-3, R-2, S-4

2004
260. The "rangeability" of a control valve mathematically defines:
(A) The maximum physical distance from the controller
(B) The maximum design pressure limit of the casing
(C) The ratio of maximum to minimum controllable flow
(D) The maximum input voltage of the smart positioner

2016
261. An ideal equal-percentage valve has a rangeability of 50. If the maximum flow is 1000 gpm, what is the minimum controllable flow?

Downloaded from www.pdf.tube

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

into electrical signals
(D) Reject unknown process disturbances without any feedback action

2008

212. Which of the following is a primary subclass of Adaptive control systems?
(A) Open-loop split-range control
(B) Single-speed floating control
(C) Model reference adaptive control
(D) Ziegler-Nichols direct tuning

2003

213. Multivariable control in industrial boilers often relies on Model Predictive Control (MPC). MPC optimizes control action by:
(A) Predicting future plant behavior and solving an optimization online
(B) Calculating the fastest valve speed randomly without feedback data
(C) Utilizing strict analog pneumatic relays within the control loop
(D) Minimizing the dynamic process degrees of freedom

2010

214. Identify the correct statement regarding power plant Multivariable control.
(A) It treats the boiler simply as a collection of non-interacting loops.
(B) It cannot utilize feed-forward designs inside the control framework.
(C) It generally relies on simple on-off logic due to safety constraints.
(D) It accounts for interactions between pressure, level, and fuel flows.

2002

215. Given the following assertion and reason, select the correct option:
Assertion (A): Adaptive control is highly beneficial for processes with non-linear characteristics or time-varying parameters, such as catalyst degradation in reactors.
Reason (R): Adaptive controllers continuously recalculate process gain and time constants, updating the control law to maintain consistent dynamic performance.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013

216. In a Self-Tuning Regulator (STR), which mathematical mechanism operates continuously in the background?
(A) A Fast Fourier Transform of the target setpoint
(B) A complete physical plant shutdown diagnostic test
(C) An online recursive parameter estimation algorithm
(D) A static Routh-Hurwitz stability array generator

2014

217. Which operational challenge in industrial boilers necessitates advanced Multivariable control rather than simple PID?
(A) The high visibility required for the operator interface
(B) The linear behavior of combustion fuel valves
(C) The lack of interaction between steam flow and feed-water demand
(D) 'Shrink and Swell' effects in the drum level during pressure transients

2013

218. Consider the following statements regarding Adaptive control:
I. Programmed Adaptation (Gain Scheduling) adjusts parameters based on measured operating conditions using pre-calculated tables.
II. Self-tuning controllers require zero initial estimates.
III. Adaptive systems are more complex and computationally demanding than fixed-parameter PID.
Which of the above statements is/are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I only

NODIA

2007

219. Match the advanced strategy in List I with its core mechanism in List II:
List I: Advanced Strategy
P. MPC
Q. MRAC
R. Gain Scheduling
S. Decoupling
List II: Core Mechanism
1. Forces plant to follow an ideal mathematical model

outer loop
(C) Significantly slower dynamically than the outer loop
(D) Tuned with heavy integral action only

2015
204. Identify the correct statement regarding Split-range control.
(A) Two separate controllers directly compete to adjust a single valve.
(B) One controller operates multiple valves in different ranges.
(C) It splits the measured variable into two separate feedback paths.
(D) The loop is limited to applications using pure on-off control logic.

2017
205. Given the following assertion and reason, select the correct option:
Assertion (A): Cascade control excels at neutralizing supply disturbances before they affect the primary controlled variable.
Reason (R): The inner loop measures and corrects the inner disturbance immediately, well before the outer loop process variable deviates.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2016
206. A common industrial application for Split-range control is:
(A) Cascading a liquid level controller directly into a flow controller.
(B) Using two separate feedback controllers to measure one temperature.
(C) Controlling temperature using both a heating valve and cooling valve.
(D) Ratioing combustion air and fuel gas mixtures in burner systems.

2018
207. Which tuning sequence is mandatory for a Cascade control system?
(A) Tune the master controller first, followed by the slave controller.
(B) Tune both controllers simultaneously using multi-variable RGA arrays.
(C) Tune the master controller while the slave controller remains un-tuned.
(D) Tune the slave first with master in manual, then tune the master.

2022
208. Consider the following statements regarding Cascade control:
I. It reduces the effect of final control element non-linearities (like valve friction).
II. It requires the secondary measured variable to be closely related to the primary variable.
III. It decreases the overall speed of response of the system.
Which of the above statements is/are INCORRECT?
(A) I and II
(B) III only
(C) II and III
(D) I only

2006
209. Match the control structure in List I with its architectural feature in List II:
List I: Control Structure
P. Single-loop
Q. Cascade
R. Split-range
S. Feed-forward
List II: Architectural Feature
1. One output driving multiple valves
2. One output driving one valve
3. Output driving another controller's setpoint
4. Input from a disturbance sensor
(A) P-1, Q-4, R-2, S-3
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-1, R-3, S-4

2019
210. In a Split-range control configuration operating a heating valve (closes 3-9 psi) and a cooling valve (opens 9-15 psi), what happens when the controller output is exactly 9 psi?
(A) Both valves are fully open.
(B) The heating valve is fully open, the cooling is closed.
(C) The system cycles uncontrollably.
(D) Both valves are fully closed.

2019
211. Adaptive control algorithms are fundamentally distinguished by their ability to:
(A) Adjust their own tuning parameters in real-time as dynamics change
(B) Function reliably without requiring any closed-loop feedback data
(C) Convert incoming pneumatic signals directly

Click Here to Buy book on Flipkart

2009

228. Consider the following statements regarding valve positioners:

I. They speed up valve response by supplying higher volumes of air to the actuator.

II. They alter the inherent flow characteristic of the valve entirely.

III. They mitigate the effects of actuator hysteresis and deadband.

Which of the above statements is/are INCORRECT?

(A) I and III

(B) II only

(C) III only

(D) I and II

2009

229. Match the hardware in List I with its specific function in List II:

List I: Hardware Component

P. I/P Converter

Q. Positioner

R. Flapper-nozzle

S. Actuator Spring

List II: Specific Function

1. Ensures stem matches command
2. Converts 4-20mA to 3-15psi
3. Provides fail-safe mechanical action
4. Translates small mechanical motion into pressure change

(A) P-2, Q-1, R-4, S-3

(B) P-1, Q-2, R-3, S-4

(C) P-4, Q-1, R-2, S-3

(D) P-2, Q-3, R-4, S-1

2002

230. A smart positioner differs from a conventional pneumatic positioner primarily because:

(A) It operates using electrical motors instead of compressed air.

(B) It is designed to function without closed-loop feedback.

(C) It is physically integrated directly into the process pump.

(D) It uses microprocessors and digital protocols for diagnostics.

2024

231. The primary mechanical components of a pneumatic spring-diaphragm actuator are:

(A) An electric motor, drive gearbox, and safety limit switches

(B) A flexible diaphragm, heavy return spring, and actuator stem

(C) A hydraulic fluid reservoir, driving piston, and rotary vane

(D) An electromagnetic voice coil, magnet, and flapper nozzle

2014

232. In an Air-to-Open (Fail-Closed) spring-diaphragm actuator, an increase in instrument air pressure causes the valve stem to:

(A) Move with the spring tension to close the valve

(B) Remain stationary while internal bypasses open

(C) Move against spring tension to open the valve

(D) Rotate ninety degrees strictly under pressure

2007

233. Which selection criterion overwhelmingly favors electric motor actuators over standard pneumatic spring-diaphragm actuators?

(A) The need for extremely rapid, instantaneous fail-safe closure using springs

(B) The necessity for operation in highly explosive, intrinsically safe required zones

(C) The requirement for the lowest possible initial capital cost per valve

(D) The absolute lack of compressed air infrastructure in remote installations

2018

234. Identify the correct statement regarding pneumatic actuator sizing.

(A) The actuator must overcome unbalanced fluid forces and packing friction.

(B) Actuator sizing is primarily determined by the electrical current available.

(C) Actuators are designed using a 3-15 psi control range in all cases.

(D) Pneumatic spring size is independent of fluid pressure.

2013

235. Given the following assertion and reason, select the correct option:

Assertion (A): Pneumatic spring-diaphragm actuators remain the industry standard for chemical processes despite advancements in electrical actuators.

Reason (R): They are mechanically simple, intrinsically explosion-proof, and inherently provide a reliable fail-safe position upon loss of power or signal.

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is not the

Downloaded from www.pdf.tube

correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021
236. The mathematical relationship governing the force generated by a pneumatic diaphragm actuator is:
(A) $F = \dfrac{\text{Pressure}}{\text{Diaphragm Area}}$
(B) $F = \text{Pressure} \times \text{Diaphragm Area}$
(C) $F = \text{Spring Constant} \times \text{Pressure}$
(D) $F = \text{Velocity}^2 \times \text{Mass}$

2008
237. Which of the following is a major disadvantage of conventional electric valve actuators compared to pneumatic types?
(A) They lack simple, mechanical spring-driven fail-safe action.
(B) They require a constant supply of clean, dry instrument air.
(C) They offer high mechanical resolution via stepper motors.
(D) They are difficult to integrate into modern digital control networks.

2006
238. Consider the following statements concerning actuator fail-safe design:
I. "Fail-safe" is dictated by the process safety requirements.
II. A cooling water valve to an exothermic reactor should generally Fail-Open.
III. A fuel gas valve to a fired heater should generally Fail-Open.
Which of the above statements is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2002
239. Match the actuator type in List I with its dominant mechanical trait in List II:
List I: Actuator Type
P. Spring-Diaphragm
Q. Pneumatic Piston
R. Electric Motor
S. Electro-hydraulic
List II: Dominant Mechanical Trait
1. High thrust/long stroke using high pressure air
2. Simple fail-safe, standard 3-15 psi
3. Very high force, high stiffness, internal fluid pump
4. Geared drive, power on loss limits fail-safe
(A) P-1, Q-2, R-3, S-4
(B) P-3, Q-1, R-4, S-2
(C) P-2, Q-4, R-1, S-3
(D) P-2, Q-1, R-4, S-3

2014
240. In evaluating the mechanics of a spring-diaphragm actuator, what defines the "bench set"?
(A) The flow coefficient and maximum valve capacity values under test bench setup
(B) The electrical calibration mapping of 4-20mA controller signals to the unit
(C) The pressure range needed to stroke the valve fully with no process pressure
(D) The mechanical torque required to manually override the actuator handwheel

2021
241. The inherent flow characteristic of a control valve relates the flow rate through the valve to the valve stem travel under the condition of:
(A) Constant differential pressure across the entire process piping system
(B) Constant differential pressure across the valve itself
(C) Continuously varying downstream pressure
(D) Laminar fluid flow conditions

2014
242. In an equal percentage valve characteristic, equal increments of valve travel produce:
(A) Equal absolute increments in the output flow rate
(B) Zero change in flow until fifty percent valve travel
(C) Immediate maximum flow at ten percent valve travel
(D) Equal percentage changes in the existing flow rate

NODIA

2010
243. The flow coefficient (C_v) is defined as the flow of water in US gallons per minute (gpm) that passes through a fully open valve at a temperature of 60°F with a pressure drop of:
(A) 1 psi
(B) 10 psi
(C) 14.7 psi (1 atm)
(D) 100 psi

2005
244. Identify the correct statement regarding "installed" flow characteristics.
(A) They are identical to inherent characteristics

in all piping geometries.
(B) They are determined during standard factory bench testing.
(C) They reflect actual flow versus travel under variable system pressure drops.
(D) They often follow a quick-opening curve when installed.

2014

245. Given the following assertion and reason, select the correct option:
Assertion (A): An equal percentage valve is typically chosen when most of the total system pressure drop occurs in the piping rather than the valve.
Reason (R): The non-linear equal percentage inherent curve compensates for the shift in available pressure drop as flow increases, often resulting in a nearly linear installed characteristic.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005

246. Cavitation inside a liquid control valve mathematically occurs when the local pressure drops below the fluid's:
(A) Critical pressure
(B) Osmotic pressure
(C) Standard atmospheric pressure
(D) Vapor pressure

2003

247. The primary difference between cavitation and flashing in a control valve is:
(A) In flashing, downstream pressure recovers above the fluid's vapor pressure.
(B) In flashing, downstream pressure stays below the fluid's vapor pressure.
(C) In cavitation, downstream pressure remains below the fluid's vapor pressure.
(D) In cavitation, the fluid is compressed into a single-phase gas state.

2009

248. Consider the following statements concerning valve sizing:
I. Sizing equations for liquids use the specific gravity of the fluid.
II. Choked flow occurs during severe cavitation or flashing, meaning further decreasing downstream pressure will not increase flow.
III. C_v values are independent of valve size.
Which of the above statements is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2023

249. Match the valve characteristic in List I with its mathematical property in List II:
List I: Valve Characteristic
P. Linear
Q. Equal Percentage
R. Quick Opening
S. Installed Characteristic
List II: Mathematical Property
1. $\frac{dQ}{dx} = \text{constant}$
2. $\frac{dQ}{dx} = k \cdot Q$
3. Maximum flow reached rapidly at low travel
4. Shifts away from inherent due to line losses
(A) P-2, Q-1, R-4, S-3
(B) P-3, Q-1, R-2, S-4
(C) P-1, Q-3, R-2, S-4
(D) P-1, Q-2, R-3, S-4

2004

250. Severe cavitation damage in control valves primarily affects the:
(A) Internal valve trim due to collapsing vapor bubbles
(B) External pneumatic actuator return springs and casings
(C) Electrical sensor connections on the valve positioner
(D) Upstream process pump impellers and mechanical seals

2019

251. Which mathematical parameter must be carefully evaluated to predict choked flow conditions in compressible gas valve sizing?
(A) The kinematic viscosity of the gas stream
(B) The critical pressure drop ratio (x_T)
(C) The ambient humidity of surrounding air
(D) The physical flash point of the process gas

2005

252. To physically prevent or mitigate cavitation damage, engineers often utilize:
(A) Larger standard single-seat globe valves in the line
(B) Multi-stage trims that drop pressure gradually in steps
(C) Quick-opening inherent valve characteristics

Click Here to Buy book on Amazon

2. Optimizes future trajectory over a horizon
3. Mathematically neutralizes MIMO interactions
4. Switches tuning parameters based on measured load regions

(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-1, S-4

2011

220. What limits the aggressive application of Adaptive Control in critical nuclear or high-pressure steam operations?
(A) The physical requirement of utilizing pneumatic hardware.
(B) The lack of robust stability proofs during extreme transients.
(C) The operational restriction regarding process dead time.
(D) The inherent speed limitation of algorithms on slow processes.

2025

221. A Current-to-Pneumatic (I/P) converter operates strictly to translate:
(A) 4-20 mA electrical signals to 3-15 psi pneumatic signals
(B) 3-15 psi pneumatic signals to 4-20 mA electrical signals
(C) High-voltage AC supply lines to standard DC current loops
(D) High-frequency digital signals to hydraulic fluid pressure

2014

222. The fundamental physical mechanism inside most I/P converters is based on:
(A) A high-speed rotating turbine driven by compressed process gas
(B) A solid-state transistor switching array with feedback
(C) An electromagnetic coil acting on a flapper-nozzle assembly
(D) A chemical gas-generating reaction cell with constant output

2009

223. What is the primary operational role of a control valve positioner?
(A) To convert the process fluid pressure into an electrical signal
(B) To measure and log the downstream fluid flow rate accurately
(C) To act independently as the primary process PID loop controller
(D) To make the physical stem position match the controller command

2019

224. Identify the correct statement regarding valve positioner calibration.
(A) Calibration involves fixing the input signal to a constant value.
(B) Calibration ensures the input corresponds exactly to the nominal spring rate.
(C) Iteratively adjusting zero and span maps the input range to full travel.
(D) Positioners require specialized factory tools and are not field-adjustable.

2014

225. Given the following assertion and reason, select the correct option:
Assertion (A): A control valve positioner acts as a secondary cascade controller within the final control element assembly.
Reason (R): It receives the control signal as a setpoint and uses internal mechanical feedback of the stem position to adjust air pressure until the stem reaches the targeted location.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

NODIA

2024

226. Which specific plant condition most strongly dictates the necessity of a valve positioner?
(A) When clean, non-viscous fluids are processed under low pressures
(B) When the controlled process exhibits zero mathematical dead time
(C) When using a purely ON-OFF floating controller for level loops
(D) When the valve faces high differential pressure or packing friction

2008

227. When calibrating an I/P converter, setting an input of 12 mA should yield a theoretical pneumatic output of:
(A) 6 psi
(B) 9 psi
(C) 12 psi
(D) 15 psi

(A) 2 gpm
(B) 10 gpm
(C) 20 gpm
(D) 50 gpm

2005
262. Which valve body style naturally offers the highest inherent C_v for a given nominal pipe size?
(A) Globe valve
(B) Angle valve
(C) Multi-stage anti-cavitation valve
(D) Full-port ball valve

2002
263. In the context of control valve dynamics, "dead-band" is primarily caused by:
(A) Mathematical errors inside the PID algorithm
(B) Packing friction and mechanical linkage backlash
(C) Pure transportation time lag in the fluid pipe
(D) Thermal expansion effects on the actuator spring

2004
264. Identify the correct statement regarding valve trim design.
(A) "Trim" refers to the external pneumatic actuator housing.
(B) Trim sizing is irrelevant to C_v calculations.
(C) Trim includes all the wetted parts that dictate flow characteristic and shutoff capability (plug, seat, stem).
(D) Trims are universally manufactured from pure copper.

2018
265. Given the following assertion and reason, select the correct option:
Assertion (A): A butterfly valve is typically not recommended for precise flow control at very small openings.
Reason (R): At small openings, high dynamic torque and high sensitivity of flow to small angular changes can cause unstable control.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2003
266. Which physical metric dictates the required shutoff class (e.g., ANSI Class IV vs Class VI) of a control valve?
(A) Permissible leakage rate when fully closed
(B) The maximum operating fluid temperature
(C) The maximum required flow capacity value
(D) The mechanical stroke speed of the actuator

2003
267. Consider the following statements concerning fluid choking in valves:
I. Choked flow limits the maximum mass flow rate for a given upstream pressure.
II. Choked flow implies the fluid velocity at the vena contracta has reached sonic velocity (for gases).
III. Choked flow can be overcome by continuously decreasing downstream pressure.
Which of the above statements is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2015
268. Match the fluid dynamics term in List I with its valve sizing relevance in List II:
List I: Fluid Dynamics Term
P. Vena Contracta
Q. Recovery Factor (F_L)
R. Specific Gravity
S. Expansion Factor (Y)
List II: Valve Sizing Relevance
1. Point of lowest pressure/highest velocity
2. Determines likelihood of cavitation
3. Density relative to water
4. Adjusts for gas density changes during pressure drop
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-4, R-2, S-3

2005
269. The liquid pressure recovery factor (F_L) specifically measures:
(A) The ratio of pressure drop across the valve to vena contracta drop
(B) How quickly the internal valve plug moves from closed to fully open
(C) The total physical weight of the wetted valve trim components
(D) The electrical signal recovery time of the smart valve positioner

Downloaded from www.pdf.tube

2012

270. In advanced installed flow analysis, why does an inherently equal-percentage valve curve "bow" upwards toward a linear shape when installed in a long piping network?

(A) The internal valve capacity coefficient changes dynamically in service.

(B) The mechanical actuator return spring physically weakens over time.

(C) Valve pressure drop decreases as flow increases due to line losses.

(D) The process fluid dynamic viscosity changes due to high flow rates.

NODIA

****

ANSWERS

1. (A) Manipulated variable
In a feedback control loop, the controller monitors the deviation between the process setpoint and the measured variable. To minimize this error, the controller dynamically calculates and adjusts the input to the process. This specific adjusted input is known as the manipulated variable, which directly influences the process behavior to restore the system to its desired target.

2. (C) The difference between the setpoint and the controlled variable
A standard feedback loop compares the desired target state with the actual measured state of the process. The comparator component subtracting these two signals generates the error signal. This dynamic difference between the setpoint and the controlled variable represents the current deviation, which the controller uses to determine the necessary magnitude of corrective action.

3. (A) Comparator
The measuring element or sensor continuously monitors the physical controlled variable of the process and converts this physical quantity into an equivalent electrical or pneumatic signal. This feedback signal is directly transmitted to the comparator, where it is compared with the reference setpoint to determine the deviation or error in the control loop.

4. (D) It compares the measured output to the setpoint to adjust the process input.
Closed loop control systems operate on the principle of feedback, where the system continuously measures the actual process output and compares it against the desired setpoint. The resulting error signal is then processed by the controller to adjust the manipulated variable or process input, ensuring that the system dynamically counteracts disturbances and maintains the target state.

5. (A) Both A and R are true and R is the correct explanation of A.
A closed loop control system achieves high accuracy because it continuously monitors the output and compares it with the target value. The resulting error signal allows the controller to adjust the input, correcting for any external disturbances or internal parameter changes. Therefore, feedback mechanism directly explains why closed loop systems provide superior accuracy over open loop configurations.

6. (C) Actuator: The device that measures the current state of the process
An actuator is not a measurement device; rather, its primary function is to execute the control command by converting the controller output signal into a physical action, such as adjusting a valve position. The component responsible for measuring the current state of the process is the sensor or transmitter, which provides feedback to the controller.

7. (D) Transducer – Converts one form of energy to another for measurement purposes
In instrumentation and process control, a transducer is defined as a device that converts a physical variable or energy form into another measurable form, typically an electrical signal. This conversion is essential for the transmitter to process and send accurate data regarding the controlled variable to the controller, making it fundamental for accurate process monitoring.

8. (A) Moving a takeoff point from ahead of a block to behind it – Multiply the takeoff branch by the block's transfer function
In block diagram reduction, moving a takeoff point from a position ahead of a block to a position behind it requires dividing the signal in the takeoff branch by the block transfer function. Multiplying the branch by the transfer function would incorrectly scale the signal, thereby violating the mathematical equivalence of the original block diagram structure.

9. (B) P-2, Q-3, R-1, S-4
Feedback control terminology is systematically defined based on loop components. The controlled variable is the measured output of the process. The manipulated variable is the altered input used to control the process. The setpoint represents the desired target output, and the disturbance is any unwanted input that drives the process variable away from its desired target.

Click Here to Buy book on Flipkart

that pipe is determined by the level difference between both tanks. Changes in the level of either tank immediately affect the other. This mutual dependence creates a physical loading effect, exemplifying a classical interacting system.

50. (C) Slower overall transient response under load disturbances
The physical interaction and loading effect between multi-capacity stages introduce an additional resistive term in the system characteristic equation. This mathematical change shifts the dominant pole closer to the origin of the complex plane, which results in a slower, much more sluggish overall transient response during load disturbances compared to non-interacting configurations.

51. (A) Multiplying their individual transfer functions
In non-interacting multi-capacity systems, the output of the first stage acts as the input to the second stage without any back-pressure or downstream loading effects. Therefore, the overall transfer function is derived by simply multiplying the individual transfer functions of each stage together in sequence, following standard rules of block diagram algebra.

52. (A) I and III
In a non-interacting multi-capacity system, the downstream stages cannot exert any back-pressure on the upstream stages. Consequently, the output from the first stage acts purely as the forcing function for the second stage. The overall transfer function denominator is simply the product of the individual denominators, represented mathematically as tau one s plus one times tau two s plus one.

53. (B) Two non-interacting first-order processes connected in series
Connecting two non-interacting first-order processes in series mathematically produces an overall second-order transfer function. Because the two individual systems have independent, real poles, the combined system characteristic equation will always yield distinct, real roots. This specific mathematical condition represents an overdamped system with a damping ratio strictly greater than one.

54. (C) 1.0
For a second-order system composed of two non-interacting first-order stages with identical time constants, the system poles are real and identical. In standard second-order systems, equal real poles occur if and only if the damping ratio is exactly equal to one. This represents a critically damped response, which is the boundary of oscillation.

55. (D) Input step → Tank 1 level rises exponentially → Flow to Tank 2 increases gradually → Tank 2 level follows an S-curve
When a step input is applied, the first tank responds immediately as a first-order system with an exponential level rise. This rising level increases the discharge flow to the second tank gradually over time. Consequently, the second tank level exhibits a delayed, sigmoidal response curve, which is commonly referred to as an S-curve.

NODIA

56. (A) I, II, III
A single first-order system responds fastest because it has only one capacity lag. Series systems introduce additional capacitance lags, slowing the response. A non-interacting series system is slower than a single stage but faster than an interacting system, because the latter suffers from downstream back-pressure that further restricts fluid transfer, making it the slowest.

57. (B) The response exhibits oscillatory overshoot before settling.
A non-interacting series system of first-order processes always yields real and negative poles. Because the roots of the characteristic equation are real, the damping ratio is greater than or equal to one, preventing any oscillation or overshoot. The step response is strictly overdamped, rising monotonically and exhibiting an S-shaped curve with an initial slope of zero.

58. (B) -0.5 and -0.333
The poles of a transfer function are the roots of the denominator polynomial. For this non-interacting system, setting the terms two s plus one and three s plus one equal to zero yields s equals negative zero point five and negative zero point three three three. These negative real roots confirm that the system is stable.

depends heavily on temperature and flow relationships, whereas a continuous stirred tank reactor relies on residence time and temperature dynamics for reactions.

20. (A) I, II and IV
In degrees of freedom analysis, variables include internal conditions and fluxes, while equations consist of mass and energy balances. External inputs are subtracted to find the control degrees of freedom because they are fixed externally. Parameters are constant values, meaning they are excluded from the list of variables in degrees of freedom calculations.

21. (B) The outlet flow resistance is assumed to be linear or linearized.
Deriving a standard linear first order transfer function for a liquid level process requires the assumption that the relationship between liquid height and outlet flow is linear. Since actual valve hydraulics follow a non-linear square-root relationship, this relationship must be linearized around a steady-state operating point to enable standard Laplace transform system analysis.

22. (D) Seconds
The time constant represents the speed of the dynamic response of a first-order system. It is calculated as the product of liquid capacitance, represented by the tank cross-sectional area, and outlet valve resistance. Since area has dimensions of squared meters and resistance has dimensions of time over area, their product simplifies mathematically to seconds.

23. (D) Gas volume and the outlet valve flow resistance
For a gas pressure vessel, the system capacitance is directly proportional to its total volume, representing the gas accumulation capacity. The system resistance is determined by the outlet valve flow restrictions. Therefore, the overall time constant, which is the product of capacitance and resistance, depends primarily on the gas volume and outlet valve flow resistance.

24. (A) The steady-state gain is equal to the outlet resistance R.
In the standard transfer function for a first-order liquid level system, the steady-state gain is represented by the variable R, which corresponds directly to the outlet flow resistance. This gain dictates the final change in liquid height relative to a change in inlet flow rate once all transient dynamics have completely settled and subsided.

NODIA

25. (A) Both A and R are true and R is the correct explanation of A.
The time constant of a liquid level process is determined by the product of tank cross-sectional area and outlet resistance. Increasing the tank area increases its capacitance, meaning a larger volume of fluid must accumulate to produce a unit change in liquid level. This larger accumulation slows the response, directly explaining the increased time constant.

26. (B) I, II and IV
Gas storage dynamics are derived using mass balance equations combined with isothermal state equations, where system capacitance remains proportional to the vessel volume. However, the assumption that valve resistance is linear regardless of pressure drop is incorrect, as gas flow through actual valves is highly non-linear and must be linearized around specific operating conditions.

27. (A) Liquid level – Cross-sectional area
In first-order process modeling, capacitance represents the capacity of the system to accumulate mass or energy per unit change in potential. For a liquid level system, this accumulation capability is determined solely by the cross-sectional area of the storage tank. This makes area the direct physical analogue to electrical capacitance in level systems.

28. (B) I, II, III and V
Deriving a first order transfer function requires formulating both unsteady state and steady state balances, then subtracting them to define deviation variables. Applying the Laplace transform directly to non-linear terms is mathematically invalid. Therefore, non-linear terms must be linearized using Taylor series expansion before applying the Laplace transform to the deviation system.

29. (D) P-3, Q-2, R-1, S-4
The physical parameters of a liquid level system govern its dynamics. Tank cross-sectional area acts as capacitance by providing accumulation capacity. Valve resistance creates flow opposition. Liquid density affects the static head pressure, while gravity represents the physical driver that

cycling frequency by allowing larger deviations before a corrective action is triggered.

90. (B) Fast-reacting high-pressure gas flow
A fast-reacting high-pressure gas flow process is highly unsuitable for ON-OFF control because of its extremely small capacity and fast dynamic response. An ON-OFF controller in this environment would switch states at an extremely high frequency, causing rapid pressure fluctuations and severe wear or mechanical failure of the physical control valve within a very short time.

91. (A) At constant speed when the error exceeds a neutral zone
In single-speed floating control, the final control element does not move if the error remains within a defined neutral zone. Once the process error exceeds these boundaries, the actuator immediately begins to move at a fixed, constant speed in the appropriate direction to correct the deviation, regardless of how large the error becomes.

92. (C) $\frac{dm}{dt} = \pm K$

The defining feature of a single-speed floating controller is that the final control element moves at a constant velocity when the error is outside the zone. Mathematically, this rate of change of controller output is represented as d m over d t equals plus or minus K, where K is the fixed speed of the the actuator.

93. (D) To prevent the final control element from hunting over time
A neutral zone is integrated into floating controllers to prevent continuous operation of the actuator under quiet conditions. Without this zone, even minute measurement noise would cause the final control element to constantly adjust and move, a phenomenon known as hunting, which causes unnecessary wear and shortens the operational lifespan of the physical actuator.

94. (C) It adjusts final element speed in discrete steps based on error thresholds.
Multiple-speed floating control improves upon the single-speed mode by introducing several discrete actuator speeds. If the process error exceeds a minor threshold, the actuator moves at a slow speed, but if the error exceeds a larger threshold, the actuator switches to a faster speed. This stepped velocity profile enables a more responsive and balanced correction.

95. (A) Both A and R are true and R is the correct explanation of A.
Floating control eventually eliminates steady-state offset because its output depends on the integral of the error over time. The actuator continues to move at a set velocity as long as the error remains outside the neutral zone. This integrating action ensures that the valve keeps adjusting until the error is returned to zero, verifying both statements.

96. (D) The speed of the final control element
The stability of a single-speed floating control system is heavily dependent on the speed of the physical actuator. If the actuator moves too quickly, the system will overshoot the neutral zone and oscillate wildly, leading to severe instability. Properly limiting the valve travel speed is critical to ensuring stable, non-oscillatory closed loop behavior.

97. (A) I and II
Single-speed floating control does not produce an output that is a linear function of the error magnitude, nor is it equivalent to proportional control. Instead, the actuator moves at a constant velocity regardless of error size, which corresponds to a pure integrating control action. Therefore, statements claiming linear or proportional equivalence are incorrect.

98. (C) P-2, Q-3, R-1, S-4
Floating control parameters have specific operational definitions. The neutral zone is a region of zero control action where the actuator remains stationary. Actuator speed outside this zone is constant at plus or minus K. Actuator position is the mathematical integral of this constant rate, while multi-speed control uses a stepped velocity profile.

99. (A) Slow-moving reversible electric motors
Floating control is most frequently implemented using slow-moving reversible electric motors. These motors allow the physical valve to open or close at a constant, fixed speed when the controller applies power. This slow movement is essential to prevent rapid overshooting of the neutral zone, helping to maintain system stability in large-capacity processes.

Downloaded from www.pdf.tube

opposes heat flow, which is mathematically analogous to electrical resistance in circuits.

40. (A) $\tau = \frac{m}{w}$

Dividing the dynamic energy balance equation by the steady-state flow term reveals the standard form of a first-order transfer function. The coefficient of the derivative term represents the system time constant. Mathematically, this term simplifies to the total mass of fluid in the tank divided by the mass flow rate, yielding the expression $\tau = \frac{m}{w}$.

41. (B) The interaction yields distinct real poles, slowing the overall response.
In an interacting multi-capacity process, the flow between the tanks depends on both levels, creating a physical loading effect. This interaction alters the characteristic equation, yielding two distinct, real poles that are further apart than in a non-interacting system. The resulting dominant pole becomes slower, which increases the overall process dynamic response lag.

42. (B) Dependent on level differences between the two connected tanks
In an interacting second-order liquid level system, the flow through the connecting valve is driven by the difference in liquid levels between the two tanks. Consequently, the flow resistance and dynamic response of the system are directly dependent on these fluid head variations, distinguishing it from non-interacting series systems where flow is purely unidirectional.

43. (A) An internal feedback loop representing the interaction
In block diagram algebra, a non-interacting system is modeled as simple blocks in series. Conversely, an interacting system requires an internal feedback loop connecting the second stage back to the first. This feedback loop mathematically represents the physical back-pressure or loading effect that the downstream process variable exerts on the upstream process stage.

44. (C) I and III
Interacting multi-capacity systems are inherently stable physical processes described by real, distinct poles, meaning they cannot have complex roots in their characteristic equation. Furthermore, the physical loading effect of interaction introduces additional resistance, which slows down the dynamic transfer, making the overall system response much more sluggish rather than faster than non-interacting configurations.

45. (A) Both A and R are true and R is the correct explanation of A.
Two interacting tanks in series respond more slowly than non-interacting ones because the fluid level in the second tank directly affects the discharge flow from the first. This back-pressure reduces the effective driving head across the connecting valve, slowing the rate of fluid transfer and explaining why the interacting system exhibits a more sluggish dynamic response.

46. (C) $\tau_1' > \tau_1$ and $\tau_2' < \tau_2$
Due to physical loading, the effective time constants of an interacting system are modified from their individual, isolated values. Mathematically, the interaction term spreads the poles of the transfer function further apart. This separation means the larger effective time constant increases relative to its isolated value, while the smaller effective time constant decreases further.

47. (B) They are real and negative.
The poles of any passive, interacting multi-capacity process without active controllers are real and negative. This mathematical property guarantees that the open-loop process is inherently stable and overdamped. The system cannot exhibit physical oscillations or instability because there are no active energy-injecting sources or complex conjugate roots in the characteristic equation.

48. (D) P-3, Q-1, R-2, S-4
Different dynamic configurations correspond to specific mathematical terms in their transfer functions. A single first-order process has a denominator of tau s plus one. Non-interacting processes in series have multiplied individual denominators. Interacting processes add an interaction term, while pure dead time is represented by an exponential term in the s domain.

49. (A) Two water tanks connected at their bases by a single open pipe
When two water tanks are connected at their bases by a single open pipe, the flow rate through

NODIA

generates the potential energy driving the fluid flow through the system discharge valve.

30. (C) When thermal transients cause internal temperature fluctuations
A standard gas storage process behaves as a first-order system under the assumption of isothermal operation. If thermal transients occur, internal temperature changes alter gas density and pressure independently of mass accumulation. This introduces additional energy balance equations, causing the overall system to deviate from a simple first-order mass-accumulation model.

31. (B) An exponential approach to a new steady-state value
The dynamic step response of a first-order thermal process is characterized by a gradual, monotonic exponential climb toward a new steady-state value. The output does not overshoot or oscillate because the system contains only one energy capacity element, which dynamically limits the speed of heat accumulation without introducing any inertial phase shifts.

32. (B) II only
In a first-order thermal process, a step change in heat input does not cause an instantaneous temperature change. Because the system possesses thermal capacitance, heat must accumulate over time, resulting in a gradual exponential temperature increase. The time constant represents this rate of heat accumulation, reaching 63.2% of its final response at one time constant.

33. (A) The change in the heat input rate
The steady-state gain of a stirred-tank heater measures the sensitivity of the output temperature to changes in process inputs. Specifically, it is the ratio of the final steady-state temperature change to the step change in the heat input rate, assuming all other inlet temperatures and process flow rates remain perfectly constant.

34. (C) $T'(t) = KM\left[1 - \exp\left(-\frac{t}{\tau}\right)\right]$
The analytical solution to a first-order differential equation forced by a step input of magnitude M yields an exponential rise. The temperature deviation variable begins at zero and rises toward the ultimate value of KM. This dynamic behavior is mathematically represented as $T'(t) = KM\left[1 - \exp\left(-\frac{t}{\tau}\right)\right]$,
Where τ is the system dynamic time constant.

35. (C) A is true but R is false.
In a first-order thermal process, increasing the overall heat transfer coefficient increases the rate of heat transfer. Since thermal resistance is the reciprocal of the heat transfer coefficient, a higher coefficient decreases thermal resistance, speeding up the thermal response. Thus, the time constant decreases, showing the assertion is true but the reason is false.

36. (A) I and II
The time constant of a stirred-tank heater is directly proportional to the liquid holdup mass, representing thermal storage capacity, and inversely proportional to the mass flow rate, representing the fluid throughput. It is directly dependent on specific heat and represents the time required to reach 63.2% of the final steady-state value, not 95%.

37. (B) Process B reaches steady state faster than Process A.
The time constant of a first-order process directly determines its speed of response to changes. A smaller time constant indicates a faster rate of accumulation and a quicker dynamic transition. Since Process B has a time constant of five minutes, which is half of Process A, it will reach its new steady state significantly faster.

38. (C) Ambient air temperature outside the insulated tank wall
When deriving the dynamic model for an insulated continuous flow heating tank, the insulation is assumed to be perfect, meaning heat loss to the surroundings is completely negligible. Consequently, the ambient air temperature outside the tank has no impact on internal energy balances and is entirely irrelevant to deriving the system time constant.

39. (D) P-2, Q-1, R-4, S-3
Thermal and electrical systems share mathematical analogies. Temperature difference acts as the driving potential, analogous to voltage. Heat flow rate represents the transport of energy, analogous to electric current. Thermal mass represents storage capacity, analogous to electrical capacitance, and thermal resistance

Click Here to Buy book on Amazon

59. (A) P-2, Q-3, R-1, S-4
In non-interacting series systems, overall gain is the product of individual gains. The overall phase lag is the sum of the individual stage lags. The initial slope of the step response remains zero at time zero due to the multi-capacity lag. Finally, each stage time constant remains independent of any downstream stages or operational changes.

60. (A) I and II
A second-order system represented by two non-interacting first-order stages has an overall time constant defined as the geometric mean of individual constants. Its damping ratio depends on the sum and product of these constants, which always mathematically results in a value greater than or equal to one, meaning a non-interacting system can never be underdamped.

61. (D) Reach the target steady-state value for the first time
In process control and system dynamics, the rise time of an underdamped second-order system is specifically defined as the time required for the response to first reach its ultimate, final steady-state target value. For underdamped systems, this occurs as the rising curve crosses the setpoint value for the first time prior to overshooting.

62. (C) Peak overshoot
Peak overshoot is a vital time domain specification that measures the maximum amount by which the process variable exceeds its final, desired steady-state value during a transient response. It is calculated as the ratio of the maximum peak height above the final steady state to the total step change magnitude, reflecting system relative stability.

63. (B) Time to reach fifty percent of the final steady-state value
The delay time is a common transient response specification used to evaluate how quickly a process begins to react. It is mathematically defined as the exact time required for the process output variable to reach fifty percent of its ultimate, final steady-state value for the first time after a step input is applied to the system.

64. (D) It is measured using a 2% or 5% tolerance band around the final value.
The settling time is the time required for the system response curve to enter and remain permanently within a specified tolerance band around the final steady-state value. This tolerance band is standardly set at either two percent or five percent, signifying that transient oscillations have sufficiently decayed and the system has effectively stabilized.

65. (B) Delay time, Rise time, Peak time, Settling time
When an underdamped system experiences a step change, the response first reaches fifty percent of its final value, representing the delay time. Next, it crosses the setpoint value, representing the rise time. It then reaches its absolute maximum value, representing the peak time, and eventually decays within the tolerance limits, representing the settling time.

66. (C) The second peak amplitude is one-fourth of the first peak amplitude.
The decay ratio measures the rate at which transient oscillations decrease in an underdamped system. A decay ratio of one-fourth, which is highly common in classical controller tuning, means that the amplitude of the second peak of the oscillation is exactly one-quarter of the amplitude of the first peak, indicating rapid damping of the system.

67. (A) It increases toward 100%.
The peak overshoot of a second-order system is mathematically determined by its damping ratio. As the damping ratio decreases toward zero, the system opposition to oscillation diminishes, allowing the transient output to swing much wider. At the mathematical limit of zero damping, the peak overshoot reaches one hundred percent, representing sustained, undamped oscillations.

68. (A) I, II and IV
Peak time is defined as the time at which the first overshoot maximum occurs in an underdamped system, which requires a damping ratio of less than one. The mathematical formula for peak time is pi divided by the damped natural frequency. Decreasing the natural frequency increases the peak time, making statement three incorrect.

69. (B) Peak overshoot
In system dynamics, peak overshoot serves as a direct indicator of relative stability. A larger overshoot indicates a lower damping ratio, which means the system is operating closer to the

NODIA

margin of instability and will exhibit prolonged oscillations. Minimizing peak overshoot is a primary objective when tuning loops for robust, stable operation.

70. (D) $\frac{4}{\zeta\omega_n}$

The settling time for a standard second-order system is determined by its exponential decay envelope, governed by the real part of the system poles, zeta times omega n. For a two percent tolerance band, the settling time corresponds to approximately four time constants, yielding the standard mathematical formula of four divided by zeta times omega n.

71. (A) II, IV, I, III

Constructing a frequency response plot systematically begins by substituting s with $j\omega$ in the transfer function. Next, the resulting complex function is rationalized into real and imaginary parts. Then, the analytical expressions for magnitude and phase angle are determined. Finally, these variables are plotted against frequency on a standard logarithmic scale.

72. (A) $20\log_{10}$(Magnitude)

In Bode plots, the amplitude ratio or magnitude is plotted in decibel units to compress a wide range of values into a manageable linear scale. Mathematically, the decibel value of a magnitude is defined as twenty multiplied by the common logarithm of that magnitude, which corresponds to the standard definition used in control engineering.

73. (B) Encirclements of the critical point $(-1, j0)$ in the complex plane

The Nyquist stability criterion determines the stability of a closed-loop system by analyzing the open-loop frequency response. Specifically, it relates the number of closed-loop unstable poles to the number of clockwise encirclements of the critical point, minus one plus j zero, in the complex plane, which represents the absolute boundary of stability.

74. (B) Phase shift needed at the gain crossover frequency to cause instability.

Phase margin is a crucial frequency domain metric representing the additional phase lag required at the gain crossover frequency to bring the closed loop system to the verge of instability. It measures the safety margin against system phase delays, with a positive phase margin indicating that the closed loop system remains stable under design conditions.

75. (A) Both A and R are true and R is the correct explanation of A.

Transportation lag introduces a pure dead time in the system without changing the magnitude of the frequency response. However, it contributes a phase shift that increases linearly with frequency, represented as negative omega times theta. This additional phase lag lowers the phase angle curve on a Bode plot, thereby directly reducing the system phase margin.

76. (A) I, II and III

For a standard first-order system, the low-frequency magnitude asymptote is zero decibels, and the high-frequency asymptote slopes at negative twenty decibels per decade. The maximum phase lag reaches negative ninety degrees at infinite frequency. The corner frequency occurs at omega equals one divided by tau, making statement four mathematically incorrect.

77. (D) A semicircle in the fourth quadrant

The Nyquist plot of an open-loop stable first-order system is constructed by plotting real versus imaginary parts for frequencies from zero to infinity. At zero frequency, the magnitude is one and the phase is zero. As frequency increases, the phase lags toward negative ninety degrees, tracing a perfect semicircle located entirely in the fourth quadrant.

78. (C) The reciprocal of the open-loop magnitude evaluated at the phase crossover frequency.

Gain margin is a fundamental indicator of system robustness, representing the factor by which open-loop gain can be increased before the system becomes unstable. Mathematically, it is defined as the reciprocal of the open-loop transfer function magnitude evaluated at the phase crossover frequency, where the system phase angle is exactly negative one hundred eighty degrees.

79. (B) P-2, Q-1, R-4, S-3

Frequency response specifications are clearly defined. Gain crossover frequency is where open-loop magnitude equals one. Phase crossover frequency is where system phase reaches negative one hundred eighty degrees. Gain margin provides a safety buffer against gain increases,

Downloaded from www.pdf.tube

while phase margin provides a safety buffer against additional phase lags in the closed loop system.

80. (D) It is unstable.
For a closed-loop system to be stable, the gain margin must be greater than one, which corresponds to a positive decibel value. A gain margin of zero point five, or negative six decibels, indicates that the loop gain has exceeded its critical limit, resulting in an unstable closed-loop system that will exhibit growing oscillations.

81. (A) I, II, III, IV
An ON-OFF controller cycle operates in a specific chronological sequence. When the controlled variable drops below the lower set limit, the controller outputs its maximum signal. As the variable rises and exceeds the upper set limit, the controller switches to its minimum output signal, repeating this sequence to maintain the process variable within boundaries.

82. (C) Prevent chattering and excessive cycling of the final control element
An ideal ON-OFF controller would switch states instantaneously at the setpoint, causing rapid cycling. To prevent this, a dead-band or differential gap is introduced. The controller only switches states when the variable crosses the outer limits of this band, reducing the switching frequency and preventing mechanical chattering and wear of the final control valve.

83. (A) Cycling is an inherent characteristic of ON-OFF control in systems with lag.
In any physical system with capacity or measurement lag, ON-OFF control results in continuous cycling of the controlled variable. Because the corrective action takes time to propagate through the process, the variable will inevitably overshoot the setpoint before the controller switches states, making oscillation an unavoidable, inherent characteristic of this control mode.

84. (D) Lack of a continuous manipulated variable, causing process oscillations
The most significant limitation of ON-OFF controllers is that the manipulated variable can only switch between two discrete states, such as fully open or fully closed. This lack of a continuous, intermediate output signal means the controller cannot achieve a steady-state balance, causing the process variable to oscillate continuously around the desired setpoint.

85. (A) Both A and R are true and R is the correct explanation of A.
Widening the dead-band of an ON-OFF controller directly reduces the frequency at which the final control element cycles. This occurs because a wider dead-band requires the controlled variable to deviate much further from the setpoint before the controller initiates a state reversal, increasing the time between switching events and confirming that both statements are true.

86. (C) Discrete manipulated variable output levels based on the error magnitude
Unlike a simple two-position controller, a discrete multi-speed controller adjusts the manipulated variable using multiple discrete output levels or speeds. The choice of speed or output level is determined by the magnitude of the error. When the error is large, the controller selects a faster corrective speed, enabling a much more responsive control action.

87. (A) 2°C
The differential gap, or dead-band, is defined as the range over which the controlled variable can deviate without triggering a change in the controller output state. It is calculated as the difference between the upper trip point of twenty-two degrees Celsius and the lower trip point of twenty degrees Celsius, which equals two degrees Celsius.

88. (A) They operate purely in the linear region of the final control element.
ON-OFF controllers do not operate in the linear region of the final control element. Instead, they drive the valve or actuator to its extreme limits, switching purely between fully open and fully closed states. This non-linear switching behavior is the defining characteristic of two position control, making the statement regarding linear operation incorrect.

89. (A) The width of the controller dead-band
In an ON-OFF control loop, the cycling frequency of the process variable is directly determined by the width of the controller dead-band. A narrow dead-band forces the controller to switch states more frequently as the variable oscillates, whereas widening the dead-band reduces the

NODIA

10. (B) Feedforward predictor
A standard feedback control loop operates solely on the deviation between the measured output and the desired setpoint. Its basic components include a measuring transmitter, an error detector, a feedback controller, and a final control element. A feedforward predictor belongs to feedforward control schemes, which measure disturbances before they affect the process, rather than standard feedback.

11. (A) Operating closer to process constraints safely
Advanced process control systems significantly reduce the variance of controlled variables. By minimizing these fluctuations, the process can safely operate much closer to physical, environmental, or economic constraints without risking safety violations. This capability to push the operation closer to its optimal performance limits yields the primary economic incentive in large-scale industrial manufacturing plants.

12. (A) I and II
The process degrees of freedom represent the number of independent variables that must be specified to fully define the system, calculated as total variables minus independent equations. Control degrees of freedom represent the number of variables that can be manipulated independently. Adding a control loop actually consumes a degree of freedom, rather than increasing it.

13. (D) The system is fully specified by its equations, leaving no variables available for manipulation.
When a mathematical model of a system exhibits exactly zero degrees of freedom, the number of independent equations matches the number of system variables. This condition means the system is fully specified and self-contained, leaving no free or independent variables available for an external controller to manipulate to achieve particular dynamic control objectives.

14. (C) The mathematical equations become inconsistent or highly redundant.
An overspecified process model occurs when there are fewer variables than independent equations, resulting in negative degrees of freedom. In this mathematical state, the equations describing the physical system are overdetermined, which means they are either highly redundant or mutually inconsistent, making it impossible to find a unique, mathematically valid steady state solution.

15. (C) A is true but R is false.
Process control systems are absolutely critical for maintaining safety boundaries in industrial chemical operations by preventing variables from exceeding physical constraints. However, implementing control loops consumes degrees of freedom by fixing manipulated variables, thereby reducing the available mathematical degrees of freedom. Therefore, the assertion is correct, but the stated reasoning is false.

16. (B) II and III
Process control aims to decrease, rather than increase, the variability of controlled variables to ensure product consistency. Additionally, effective control loops stabilize process operations, which reduces wear on physical equipment rather than shortening its lifecycle. Therefore, statements indicating increased variability and reduced equipment lifecycle are incorrect representations of incentives for process control.

17. (A) Control degrees equal dynamic degrees minus externally fixed variables.
The dynamic degrees of freedom represent the total number of independent variables that describe the dynamic behavior of a system. The control degrees of freedom determine how many of these variables can be adjusted by controllers, which equals the dynamic degrees of freedom minus any variables fixed by external operating constraints or operations.

18. (C) The reduction in process variability allowing optimal setpoint shifts
Reducing process variability is the most powerful justification for implementing new control systems. By stabilizing the process, the variance is reduced, which allows operators to shift the operating setpoints closer to their physical or economic limits. This shift directly maximizes product yield or energy efficiency, generating highly significant economic returns for the facility.

19. (A) P-3, Q-1, R-2, S-4
Process degrees of freedom are determined by design characteristics. A liquid tank with a pump has levels as the dominant characteristic. Binary distillation involves complex, multi-variable control requirements. A simple heat exchanger

Click Here to Buy book on Flipkart

100. (D) Floating control integrates the error to eliminate offset, unlike proportional control.
The key difference between floating control and proportional control lies in their steady-state performance. A proportional controller produces an output directly proportional to the current error, which inherently results in a steady-state offset. In contrast, floating control integrates the error over time, continuing to adjust the valve until the steady-state error is completely eliminated.

101. (B) $p(t) = K_c e(t) + p_s$
The ideal equation for a Proportional controller defines the output signal as a linear function of the current error. This relationship is mathematically formulated as $p(t)$ equals $K_c e(t)$ plus p_s, where K_c is the controller gain and p_s represents the bias output, which is the control signal value when the error is zero.

102. (C) $PB = \frac{100}{K_c}$

Proportional band and controller gain are inversely related parameters that define the sensitivity of a proportional controller. The proportional band represents the range of error required to drive the controller output through its entire operating span. Mathematically, this relationship is expressed as proportional band equals one hundred divided by the controller gain, K_c.

103. (D) The permanent residual error remaining after a process load change
Steady-state offset is a fundamental limitation of proportional-only control. Following a sustained load disturbance or setpoint change, the controller requires a continuous, non-zero error to maintain the manipulated variable at its new operating position. Consequently, a permanent residual difference, known as the offset, remains between the process variable and the target setpoint.

104. (A) A 100% proportional band means the controller gain is 1.0.
The mathematical relationship between proportional band and controller gain is defined by an inverse ratio. Specifically, proportional band equals one hundred divided by the gain. Consequently, when the proportional band of a controller is set to exactly one hundred percent, the corresponding controller gain is mathematically equal to one point zero, representing unit sensitivity.

105. (A) Both A and R are true and R is the correct explanation of A.
Increasing the proportional gain decreases the steady-state offset because the controller produces a larger output change for the same size error. To maintain the process at its new operating point under a load change, a smaller residual error is sufficient to sustain the corrective action, confirming both the assertion and reasoning are true.

106. (B) The need for a sustained error to maintain the adjusted manipulated variable
The offset mechanism in a proportional-only liquid level control system is caused by the controller mathematical formulation. When a sustained load change occurs, the outlet flow changes, requiring a new control valve position. Because a proportional controller cannot adjust its output without a corresponding error, a sustained level deviation must exist to maintain this new position.

107. (A) Increased K_c – Increased system oscillation
Altering the controller gain directly impacts loop stability and dynamic response. Increasing the proportional gain makes the loop more sensitive and aggressive, producing larger corrective actions for any given error. This increased sensitivity reduces the system damping, leading to larger transient oscillations and bringing the closed loop system closer to the margin of instability.

108. (A) I and II
Proportional control is a memoryless mode that responds instantaneously and solely to the current magnitude of the error. It cannot anticipate future error trends because it lacks derivative action, and it cannot guarantee zero steady-state error because it lacks integral action. Therefore, only statements regarding instantaneous response and lack of anticipation are correct.

109. (D) P-4, Q-1, R-2, S-3
The components of a proportional controller have distinct operational definitions. The bias represents the base controller output when the error is zero. The error is the difference between the setpoint and the measured variable. The

Downloaded from www.pdf.tube

affect the controlled variable. By calculating the necessary adjustment using a predictive process model, the controller takes preemptive corrective action. This strategy theoretically eliminates the error before it can manifest in the final system output.

192. (C) Accurate models of process and disturbance dynamics must be known
Successful implementation of purely feed-forward control depends heavily on having accurate mathematical models of the process and disturbance dynamics. Because this scheme does not measure output error to make adjustments, any modeling inaccuracy or unmeasured disturbance leads to persistent offset that cannot be corrected by the feed-forward controller alone.

193. (B) Feed-forward control
Ratio control is a specialized class of feed-forward control. In this configuration, the flow rate of an uncontrolled primary stream is continuously measured and used to calculate the required setpoint for a controlled secondary stream. This ensures a constant proportional ratio between the two streams, preventing deviations preemptively.

194. (D) It maintains a stoichiometric ratio of reactants entering a reactor.
Ratio control is widely used in chemical plants to maintain a stoichiometric ratio of reactants entering a reactor. This configuration ensures that chemical reactions occur efficiently and safely by dynamically adjusting one feed stream in proportion to measured variations in the main feed stream, preventing unwanted chemical imbalances.

195. (A) Both A and R are true and R is the correct explanation of A.
Pure feed-forward control is rarely implemented on its own because it cannot correct for unmeasured disturbances or inaccuracies in the predictive mathematical model. Combining feed-forward with a feedback loop provides the ideal solution, where the feed-forward loop rejects major measured disturbances and the feedback loop eliminates remaining steady state errors.

196. (C) $G_{ff} = -\frac{G_{load}}{G_{process}}$
The ideal feed-forward transfer function is mathematically defined as the negative ratio of the load disturbance transfer function to the process transfer function. This formulation ensures that the corrective action calculated by the controller perfectly balances and cancels out the dynamic effect of the measured disturbance on the process variable.

NODIA

197. (A) Blending two separate fuel streams in a fixed proportion
Blending two separate fuel streams in a fixed proportion is a classic example of ratio control. The controller continuously measures the flow of the primary fuel stream and automatically adjusts the control valve on the secondary stream to maintain the exact pre-established ratio, ensuring consistent mixture quality during load changes.

198. (B) I and III
Feed-forward control improves the rejection of measured disturbances without introducing instability to the closed loop system. Because the feed-forward path operates outside the feedback loop, it does not alter the roots of the closed loop characteristic equation, meaning it cannot cause instability even if high gains are applied.

199. (B) P-1, Q-2, R-3, S-4
Different control schemes possess distinct defining traits. Feedback control acts on measured error, while feed-forward control acts on measured disturbances. Ratio control maintains a strict proportionality between two variables. Cascade control features a nested architecture where the master controller sets the target setpoint for the slave controller.

200. (C) The controller drops the secondary flow by 50% to maintain the ratio
If the primary stream drops by fifty percent, the ratio controller immediately detects the change in this wild flow. To maintain the pre-established stoichiometric proportion, the controller automatically reduces the secondary stream flow rate by exactly fifty percent as well, ensuring the correct ratio is maintained throughout the transient event.

201. (D) Two nested controllers, two sensors, and one final control element
A cascade control configuration requires at least two nested controllers, two separate sensors, and a single final control element. The primary master controller monitors the main process variable and calculates the setpoint for the secondary

120. (A) The derivative action is applied directly to a setpoint step change.
A derivative kick is an unwanted spike in the controller output that occurs when a sudden step change is made to the setpoint. Because the derivative term is mathematically sensitive to the rate of change of the error, a step change in setpoint produces an infinite derivative, causing a violent kick in the control valve.

121. (B) $p(t) = K_c\left[e(t) + \frac{1}{\tau_I}\int e(t)\,dt + \tau_D\frac{de(t)}{dt}\right]$
The ideal equation for a composite proportional-integral-derivative controller combines all three control modes. In this formulation, the controller output is proportional to the sum of the current error, the integral of the error over the integral time constant, and the derivative of the error multiplied by the derivative time constant, as shown mathematically.

122. (B) Fast-responding loops where steady-state offset must be eliminated and noise makes derivative action undesirable.
A proportional-integral controller is ideal for fast-responding processes like flow control loops, where steady-state offset must be completely eliminated. Because these systems are exceptionally fast, they are often prone to high-frequency measurement noise. Since derivative action would amplify this noise, a proportional-integral controller provides the optimal balance of speed and stability without noise amplification.

123. (A) $G_c(s) = K_c\left(1 + \frac{1}{\tau_I s} + \tau_D s\right)$
Taking the Laplace transform of the ideal time-domain proportional-integral-derivative equation yields its transfer function representation. In the s-domain, the proportional term is one, the integral term is represented as one divided by tau_I times s, and the derivative term is tau_D times s, all scaled by the controller gain, K_c, matching the selected formula.

124. (B) II and III
Proportional-derivative controllers are effective for stabilizing loops because the derivative term adds phase lead, improving safety margins. However, they are highly sensitive to high-frequency measurement noise, which the derivative term amplifies. Furthermore, because they lack an integral term, proportional-derivative controllers cannot eliminate steady-state offset, confirming that statement one is incorrect.

125. (A) Both A and R are true and R is the correct explanation of A.
In commercial proportional-integral-derivative controllers, the derivative term is implemented with a first-order lag filter. This modification is necessary because pure derivative action possesses infinite gain at high frequencies, which would severely amplify measurement noise. The filter limits the high-frequency gain, ensuring stable valve operation and proving both the assertion and reasoning are true.

126. (C) Proportional-Integral-Derivative
The composite proportional-integral-derivative controller is universally referred to as a three-mode controller in industrial instrumentation. This terminology arises because it incorporates three distinct mathematical modes of error correction: proportional mode for present error, integral mode for past accumulated error, and derivative mode for future predictive correction based on the rate of error change.

127. (B) Temperature loop – PID control
Temperature control loops are characterized by large thermal capacities and significant dynamic lags, which make them sluggish. Implementing a full proportional-integral-derivative controller is highly recommended for these processes. The derivative term provides crucial predictive action to counteract the thermal inertia, successfully minimizing temperature overshoots and accelerating the system settling time.

128. (D) Accumulation of integral term during actuator saturation, delaying recovery.
Integral windup is a critical control loop phenomenon that occurs when a large, sustained error drives the final control element to its maximum or minimum saturation limit. Since the valve cannot open or close further, the integral term continues to accumulate or wind up, delaying recovery and causing severe process overshoot once the error finally reverses.

129. (A) P-3, Q-2, R-1, S-4
The frequency response traits of controllers depend on their active terms. An ideal proportional controller maintains a constant phase angle of zero degrees. A proportional-integral controller introduces a phase lag at low

Click Here to Buy book on Amazon

frequencies. A proportional-derivative controller adds a phase lead, while a full PID controller provides high low-frequency gain and high-frequency phase lead.

130. (C) The derivative action counters thermal inertia and minimizes overshoot.
Batch reactors exhibit significant thermal inertia and slow heat transfer rates, which make temperature control challenging. While a proportional-integral controller can eliminate offset, it often causes large temperature overshoots as it recovers from start-up. Adding derivative action provides predictive capability, countering the thermal lag and slowing the heating rate as the temperature approaches the setpoint.

131. (A) $\int |\, e(t)\, | dt$

The Integral of Absolute Error is a standard performance index used to evaluate the quality of a control system response. Mathematically, it is formulated as the integral over time of the absolute value of the error. This criterion treats positive and negative deviations equally and does not vary the weight of the error based on time.

132. (D) ISE (Integral of Squared Error)
The Integral of Squared Error criterion is mathematically formulated as the integral of the squared error over time. Because the error is squared, larger deviations are penalized much more heavily than smaller ones. Consequently, tuning based on this index prioritizes the rapid suppression of large initial transient errors, even if it results in small, persistent oscillations.

133. (B) Errors persisting over long duration
The Integral of Time-weighted Absolute Error criterion includes a time variable within the integrand, multiplying the absolute error. This weighting factor means that errors occurring later in the transient response are penalized much more heavily than initial errors. Consequently, tuning based on this criterion is highly effective at eliminating long-duration, persistent oscillations and tails.

134. (C) ITAE typically produces a tuning that minimizes long-duration tails in the response curve better than ISE.
Tuning a controller using the Integral of Squared Error index focuses heavily on reducing the initial, large deviations, often allowing small oscillations to persist. In contrast, the Integral of Time-weighted Absolute Error index penalizes late-stage errors more severely. Therefore, tuning with this index produces responses with much shorter settling times and fewer long duration oscillations.

135. (A) Both A and R are true and R is the correct explanation of A.
The Integral of Time-weighted Absolute Error is widely favored for controller tuning because it incorporates a time-multiplier that penalizes persistent errors heavily while tolerating inevitable initial step deviations. This balanced penalty system produces tuned responses that exhibit minimal oscillation, rapid settling, and zero steady-state offset, confirming that both the assertion and reasoning are true.

136. (C) $\int_0^{\infty 2} e^2(t)\, dt$

The Integral of Squared Error evaluates controller performance by squaring the error before integration over an infinite time horizon. This mathematical squaring heavily penalizes large transient errors compared to small steady state errors. This feature ensures that the system quickly suppresses large fluctuations, making it a standard metric for optimizing transient responses in control system design.

137. (D) ISE
The Integral of Squared Error criterion is ideal for applications where large errors must be eliminated rapidly. Because the error is squared, larger deviations from the setpoint contribute disproportionately to the integrated value. Consequently, tuning based on this metric prioritizes aggressive corrective actions to quickly suppress major disturbances, accepting minor subsequent oscillations as a necessary compromise.

138. (B) II only
The statement regarding the squaring of the error is incorrect because squaring actually penalizes large errors much more severely than small ones. For deviations smaller than unity, the squared value becomes smaller than the original error. Therefore, this criterion is highly sensitive to large transient spikes while remaining relatively indifferent to small steady state offsets that persist.

NODIA

139. (B) P-2, Q-1, R-3, S-4
Different error criteria serve distinct tuning objectives. Squaring the error suppresses large initial deviations. Multiplying the absolute error by time penalizes long duration oscillations to ensure faster settling. Integrating the absolute error provides a balanced general suppression, while direct algebraic integration can cancel positive and negative errors, yielding a misleading zero total value.

140. (B) Total absolute area under the error curve
The Integral of Absolute Error criterion measures the total area under the absolute error curve over time. By taking the absolute value, it prevents positive and negative deviations from canceling each other out. Minimizing this integral produces a well behaved response with balanced suppression of both large transient errors and long lasting steady state offsets.

141. (A) First-order system plus dead time
The Cohen Coon method is an open loop tuning strategy that approximates complex, high order chemical processes. It simplifies these dynamics into a first order plus dead time model. This standard model is defined by three parameters: the steady state process gain, the apparent time constant, and the apparent dead time representing physical transport delays.

142. (C) Apply an open-loop step test in manual mode and record the response
Extracting parameters for open loop tuning requires decoupling the controller from automatic feedback. The operator places the controller in manual mode and introduces a sudden, stepped change to the control variable. Recording the resulting transient process variable response yields the reaction curve from which the process gain, dead time, and time constant are mathematically calculated.

143. (D) Process gain (K_p), Dead time (θ), Time constant (τ)
The three essential parameters obtained from the open loop process reaction curve are the process gain, the apparent dead time, and the primary process time constant. Together, these values completely define the simplified first order plus dead time model. These parameters are then used in empirical formulas to calculate the appropriate controller tuning coefficients.

144. (C) It is sensitive to load disturbances during the test.
A major limitation of the open loop process reaction curve method is its susceptibility to external load disturbances during testing. Because the controller is in manual mode, any sudden environmental or process fluctuation directly distorts the recorded response curve. This corruption leads to highly inaccurate parameter estimates and subsequent poor controller performance when switched to automatic mode.

145. (A) Both A and R are true and R is the correct explanation of A.
The Cohen Coon tuning equations were developed specifically to improve upon the classical Ziegler Nichols settings for highly delayed processes. By explicitly incorporating the ratio of dead time to the process time constant within the formula design, this method successfully computes highly robust control coefficients even when the system exhibits relatively large transport lags.

146. (D) The time from the step input to the tangent-baseline intersection
The apparent dead time is determined graphically from the process reaction curve. A tangent line is drawn at the point of maximum slope, which is the inflection point of the response. The dead time is then measured as the time interval between the initial step input change and the intersection of this tangent line with the initial baseline.

147. (A) $K_p = \dfrac{\text{Change in Process Variable}}{\text{Change in Controller Output}}$
The steady state process gain represents the sensitivity of the process variable to changes in the controller output. It is calculated as the ratio of the total ultimate change in the process variable at steady state to the magnitude of the step change applied to the controller output during the open loop test.

148. (B) II only
The process reaction curve method does not require continuous process cycling to find parameters. Instead, it is a single step, open loop test performed in manual mode. It uses a single step response to approximate the system as a first order transfer function with dead time, avoiding the risks associated with sustained oscillations.

Downloaded from www.pdf.tube

149. (A) P-3, Q-2, R-4, S-1
In open loop characterization, each physical parameter maps to a specific graphical extraction method. The tangent line is drawn at the curve inflection point. The dead time is the delay from the step to the tangent intersection with the baseline. The process gain is the steady state output change divided by the input step magnitude.

150. (D) It maintains stability and causes less process disruption.
A major advantage of open loop process reaction curve testing in industrial plants is that it avoids driving the system to its stability limit. Unlike closed loop oscillation methods, it uses a controlled manual step test that maintains process stability, preventing hazardous cycling and minimizing overall disruption to ongoing plant operations.

151. (B) Automatic mode with only proportional control action active
The Ziegler Nichols ultimate cycle method requires the controller to be in automatic closed loop mode with the integral and derivative actions entirely deactivated. By slowly increasing the proportional gain of the controller, the feedback loop is driven to the verge of instability, which allows the operator to observe and record sustained oscillations.

152. (C) Sustained, constant-amplitude oscillations
The ultimate gain is defined as the specific proportional controller gain that causes the closed loop system to exhibit sustained, constant amplitude oscillations. At this critical threshold, the system lies exactly on the boundary of stability, and the closed loop poles are located precisely on the imaginary axis of the complex plane.

153. (D) The period of sustained oscillations at ultimate gain
The ultimate period is the time required to complete one full cycle of the sustained, constant amplitude oscillations observed at the ultimate controller gain. This time duration is a fundamental dynamic characteristic of the process, which is then used directly in the empirical formulas to calculate the integral and derivative time constants.

NODIA

154. (B) $0.5K_u$
According to the empirical Ziegler Nichols tuning guidelines, a pure proportional controller should have its gain set to exactly half of the ultimate gain. This setting provides a reasonable compromise between achieving a rapid response and maintaining a stable system, typically yielding a quarter wave decay ratio in the closed loop transient response.

155. (B) $K_c = 0.6K_u$, $T_i = 0.5P_u$, $T_d = 0.125P_u$
The standard formulas for tuning a three mode PID controller via the Ziegler Nichols closed loop method use the ultimate gain and ultimate period. The proportional gain is set to sixty percent of the ultimate gain, the integral time is set to half the period, and the derivative time is set to one eighth of the period.

156. (B) $\frac{1}{4}$ (quarter-wave decay)
The classic Ziegler Nichols tuning rules are designed to target a quarter wave decay ratio. This means the amplitude of each subsequent oscillation peak is exactly one fourth of the preceding peak. This target represents an aggressive response that settles relatively quickly, though it displays significant overshoot in the initial transient phase.

157. (A) It is highly suitable for open-loop unstable processes.
The closed loop Ziegler Nichols method is generally unsuitable for processes that are unstable in open loop. Intentionally driving such sensitive or hazardous systems to the verge of sustained, constant amplitude oscillations is highly dangerous. Doing so can easily trigger runaways or physical damage, making alternative safe simulation techniques far more preferable.

158. (D) 3.33 seconds
For a proportional integral controller, the Ziegler Nichols closed loop rules recommend setting the integral time constant to the ultimate period divided by one point two. Given an ultimate period of four seconds, dividing four by one point two yields approximately three point three three seconds, which optimizes the integral reset rate for the system.

159. (D) P-2, Q-3, R-1, S-4
The proportional gain settings in the Ziegler Nichols ultimate cycle method vary systematically by controller type. A pure proportional

controller uses half of the ultimate gain, while a proportional integral controller reduces this to forty five percent. A full three mode controller utilizes sixty percent of the ultimate gain to maximize response speed.

160. (A) Both A and R are true and R is the correct explanation of A.
A first order system without dead time has a maximum theoretical phase lag of ninety degrees at high frequencies. Sustained oscillations require a total phase lag of one hundred and eighty degrees around the feedback loop. Therefore, proportional control alone cannot induce instability or continuous cycling, rendering ultimate cycle tuning methods completely inapplicable.

161. (B) Provide positive phase shift to improve the phase margin
A lead compensator is designed primarily to inject positive phase shift into the control loop over a targeted frequency range. This positive phase contribution directly increases the system phase margin, which improves stability and enhances the speed of the transient response, effectively making the system respond faster to error inputs.

162. (D) $\alpha > 1$
For the standard compensator transfer function, the parameter alpha must be strictly greater than one for a lead compensator. This condition ensures that the zero is located closer to the origin on the real axis than the pole, which mathematically yields a positive phase angle and amplifies high frequency gains.

163. (A) Attenuates high-frequency gain and introduces phase lag
In the frequency domain, a lag compensator acts primarily by attenuating high frequency gains while introducing a negative phase shift. This high frequency attenuation reduces the overall loop gain cross over frequency, thereby improving the steady state performance and stability margins of the closed loop system without destabilizing the low frequency operation.

164. (C) A Lead compensator acts like a high-pass filter, improving transient response.
A lead compensator functions similarly to a high pass filter, passing high frequencies more easily than low ones. This frequency response speeds up the transient performance of the system by adding positive phase. In contrast, lag compensators behave as low pass filters, designed to improve steady state accuracy by boosting low frequency gains.

165. (A) Both A and R are true and R is the correct explanation of A.
A lag lead compensator combines the distinct features of both networks. The lag portion provides high gain at low frequencies, which directly minimizes steady state error. Meanwhile, the lead portion provides positive phase shift at higher frequencies, which preserves adequate stability margins and ensures a rapid transient response to setpoint changes.

166. (B) II only
The statement asserting that lead compensators decrease the overall system bandwidth is incorrect. Lead compensators actually increase the gain crossover frequency and expand the closed loop bandwidth. This wider bandwidth is what physically allows the system to respond more rapidly to inputs and settle much faster during transient disturbances.

167. (A) The pole is to the right of the zero (closer to the origin).
In a lag compensator, the pole must be placed closer to the origin than the zero on the real axis of the complex plane. This structural configuration ensures that the low frequency gain is amplified relative to the high frequency gain, which directly reduces the steady state error of the system.

168. (C) P-2, Q-1, R-4, S-3
Each type of compensator addresses a specific control design limitation. Lead compensators primarily enhance transient speed and loop stability. Lag compensators improve steady state accuracy without heavily degrading overall stability. Combined lag lead networks optimize both steady state and transient performance, while basic amplifiers scale the overall gain evenly across all frequencies.

169. (D) $\sin(\phi_m) = \dfrac{\alpha - 1}{\alpha + 1}$
The maximum phase lead angle provided by a lead compensator is mathematically determined by the parameter alpha, which is the ratio of the zero frequency to the pole frequency. The sine of this maximum angle equals the difference of

Click Here to Buy book on Flipkart

alpha and one, divided by the sum of alpha and one.

170. (A) Resistor-Capacitor (RC) network values
In classical analog electronic controllers, lead lag compensators are implemented using active operational amplifier circuits. Physically tuning these compensators is achieved by adjusting the variable resistors and capacitors within the feedback networks. Changing these RC component values directly alters the pole and zero locations, shifting the frequency response.

171. (B) $1 + G(s)H(s) = 0$
The characteristic equation of a feedback control system is derived by setting the denominator of the closed loop transfer function to zero. For a standard negative feedback loop, this denominator is one plus the open loop transfer function, representing the system self excitation pathways that dictate transient stability.

172. (B) All roots have negative real parts.
For a linear time invariant system to be strictly stable, all roots of its characteristic equation must lie entirely in the left half of the s plane. This means every root must possess a strictly negative real part, which ensures that any transient response decays exponentially to zero over time.

173. (A) The number of sign changes in the first column
The Routh stability criterion states that the number of roots of the characteristic polynomial with positive real parts is exactly equal to the number of sign changes in the first column of the Routh array. Each sign change indicates an unstable root located in the right half of the complex plane.

174. (C) It indicates the presence of symmetrically located roots.
A row consisting entirely of zeros in a Routh array indicates the presence of roots that are symmetrically located about the origin in the complex plane. These roots can be pairs of purely imaginary roots, real roots of equal magnitude but opposite signs, or complex conjugate roots forming a symmetric pattern.

175. (D) A is false but R is true.
The Routh Hurwitz criterion is an algebraic method that determines stability without calculating the actual numerical values of the roots. Therefore, the assertion that it computes the exact values of complex roots is false. It relies solely on the polynomial coefficients to assess the signs of the real parts.

176. (A) I and II
The Routh Hurwitz test is a powerful algebraic stability criterion. A necessary but not sufficient condition for closed loop stability is that all coefficients of the characteristic polynomial must be strictly positive. However, it cannot handle pure dead time directly without using mathematical approximations, as delay terms are non polynomial.

NODIA

177. (C) 10
Constructing the Routh array for the characteristic polynomial shows that the first row contains coefficients one and eleven, while the second row contains six and six. The first element of the third row is calculated by multiplying six by eleven, subtracting one multiplied by six, and dividing by six, which mathematically yields ten.

178. (D) Padé approximation
Transportation lag introduces exponential terms that cannot be directly analyzed using the polynomial based Routh Hurwitz criterion. To resolve this, engineers apply a Pade approximation to convert the transcendental delay term into a rational algebraic fraction. This approximation allows the characteristic equation to be written in a polynomial format.

179. (A) P-3, Q-4, R-2, S-1
The Routh array construction provides specific conditions that map directly to system stability properties. Having no sign changes in the first column indicates a strictly stable system. Two sign changes indicate two unstable roots. A row of zeros indicates potential marginal stability, while a negative coefficient in the polynomial implies instability.

180. (C) $K > 0$
For a second order characteristic polynomial to represent a strictly stable system, all of its coefficients must be strictly positive. In this specific equation, the coefficient of the middle term is K. Therefore, the parameter K must be strictly greater than zero to ensure that all closed loop roots remain stable.

181. (A) A single manipulated variable structurally affects more than one controlled variable.
Interaction in multivariable processes occurs because changing a single manipulated variable to adjust one process output simultaneously influences other controlled outputs. This cross coupling distorts the independent operation of separate single loop controllers, often causing control system instability unless the interactions are properly evaluated and decoupled using multivariable design techniques.

182. (D) Pair manipulated and controlled variables to minimize interaction
The Relative Gain Array is a mathematical matrix technique used in multivariable control design. It assesses the steady state interactions between different control channels. By evaluating these interactions, engineers can determine the most effective pairings of manipulated and controlled variables, minimizing the detrimental effects of cross coupling between loops.

183. (B) 1
A fundamental algebraic property of any Relative Gain Array matrix is that the sum of the elements in any row or any column must always equal exactly one. This normalized property holds true regardless of the units, scaling, or steady state gain values of the physical process being modeled.

184. (C) Pair variables where λ_{ij} is close to 1.0
When utilizing the Relative Gain Array, the optimal pairing strategy is to couple manipulated and controlled variables whose relative gain element is closest to one. A value near one indicates that closing the other loops has minimal impact on this channel, ensuring the loop behaves almost independently with negligible interaction.

185. (A) Both A and R are true and R is the correct explanation of A.
In binary distillation columns, adjusting the reflux rate changes the internal liquid flow throughout the entire tower. This variation directly impacts both top product purity and bottom product purity. Because of this strong internal physical interaction, the column behaves as a highly coupled multivariable system requiring careful loop pairing analysis.

186. (A) Severe interaction; loop 1 gain doubles when loop 2 closes
A relative gain of zero point five indicates severe loop interaction within a multivariable system. Mathematically, it means that the process gain of the primary loop doubles when the secondary loop is closed. This high sensitivity makes independent single loop control highly oscillatory and difficult to stabilize.

187. (B) Decoupler
A decoupler is a specialized control component designed to neutralize physical interactions in multivariable systems. By calculating cross coupling compensations, it generates corrective signals that cancel out the influence of one control loop on another. This mathematical decoupling allows independent controllers to regulate their respective variables without interfering with each other.

188. (A) I only
The statement asserting that the Relative Gain Array requires dynamic transfer function matrices is incorrect. The standard array is calculated strictly from the steady state gain matrix of the process. It serves as a static analysis tool that is completely independent of transient dynamics and scaling units.

189. (A) P-3, Q-4, R-1, S-2
Different values in the Relative Gain Array dictate specific variable pairing recommendations. A relative gain of one indicates no interaction and represents perfect pairing. A value of zero means no direct effect, while a value of zero point five implies severe interaction. Negative values indicate unstable closed loop interactions that must never be paired.

NODIA

190. (C) Manipulated variable that affects the outlet temperature and interacts with other loops
In a heat exchanger, the steam valve position serves as a manipulated variable used to regulate the fluid outlet temperature. However, adjusting this valve also alters other process variables like internal pressures. This behavior illustrates loop interaction, as a single input change influences multiple controlled parameters.

191. (D) Measure disturbances and take preemptive corrective action
Feed-forward control is designed to measure major process disturbances directly before they

controller gain represents the sensitivity of the control action, while the output is the actual control signal sent to the valve.

110. (C) 4.0
The relationship between the proportional band and the controller gain is defined by an inverse mathematical formula, where gain equals one hundred divided by the proportional band. For a proportional band of twenty-five percent, dividing one hundred by twenty-five yields a controller gain of exactly four point zero, which represents high control loop sensitivity.

111. (B) Eliminate the steady-state offset
Adding integral action to a proportional controller is primarily done to eliminate the steady-state offset. The integral term continuously integrates the error over time, forcing the controller output to keep changing as long as any non-zero error exists. This continuous adjustment ceases only when the process variable perfectly matches the setpoint, eliminating the offset.

112. (D) Changing the controller output as long as a non-zero error exists
Integral control action functions by generating an output that is proportional to the accumulated area under the error curve over time. Mathematically, this means the controller output will continuously change as long as a non-zero error remains in the system, forcing the control valve to adjust until the steady-state error is driven to zero.

113. (A) Anticipating future errors based on the rate of error change
Derivative control action assesses the slope or rate of change of the process error over time. By calculating this derivative, the controller can estimate the future direction and velocity of the error, initiating a predictive corrective action to counteract the deviation before it grows larger, which significantly reduces system overshoot and settling time.

114. (C) It cannot be used alone as it has no output when error is constant.
Derivative control action is proportional to the rate of change of the error signal. Under steady state conditions, when the process error remains constant, the derivative of the error is exactly zero, resulting in zero derivative output. Consequently, derivative action cannot be used alone and must be combined with proportional or integral control modes to function.

115. (C) A is true but R is false.
Derivative action is highly sensitive to measurement noise because high-frequency noise has rapid, large slopes, which the derivative term amplifies into massive control output fluctuations. However, derivative control does not increase the low-frequency steady-state gain of the system; that is the role of integral control. Therefore, the assertion is true, but the stated reason is completely false.

116. (A) I, II, III and IV
Integral control introduces a phase lag that reduces relative stability, while derivative action adds a phase lead that stabilizes the loop. The integral effect is inversely proportional to the reset time, meaning a smaller reset time increases the reset action. Additionally, derivative action inherently amplifies high-frequency noise, confirming that all four statements are correct.

117. (B) Integral time (T_i) or reset rate
In a standard proportional-integral-derivative formulation, the strength of the integral control action is governed by the integral time constant, also known as the reset time, or its inverse, the reset rate. A smaller integral time increases the contribution of the integral term, resulting in more aggressive integration of the error to eliminate steady-state offset.

118. (C) $\frac{1}{T_i}$
In industrial control systems, the reset rate is defined as the number of times per minute that the integral action repeats the proportional action. Mathematically, the reset rate is the exact reciprocal of the integral time constant. Consequently, this relationship is formulated as reset rate equals one divided by the integral time constant, T_i.

119. (D) P-3, Q-1, R-2, S-4
Different feedback control modes yield specific dynamic effects. Proportional control provides a baseline correction but inherently leaves a steady-state offset. Integral control integrates the error over time to eliminate this offset. Derivative control acts predictively by anticipating future error changes, whereas ON-OFF control induces a continuous, sustained oscillation of the process variable.

Downloaded from www.pdf.tube

slave controller, which directly regulates a faster inner loop variable via the valve.

202. (A) Setpoint for the slave (inner) controller
In cascade control, the master controller manages the slower, outer process variable. The output of this master controller is wired directly as the setpoint for the inner slave controller. This nested architecture allows the slave loop to handle localized disturbances before they can impact the primary process variable.

203. (B) Significantly faster dynamically than the outer loop
For cascade control to operate successfully, the inner slave loop must respond significantly faster than the outer master loop. This speed difference allows the slave controller to suppress high frequency disturbances inside the inner loop completely before they have time to propagate and cause deviations in the primary outer variable.

204. (B) One controller operates multiple valves in different ranges.
Split-range control involves a single controller driving multiple control valves that operate over different sub ranges of the controller output signal. This configuration is commonly used when a process requires different physical media, such as heating and cooling, to regulate a single process variable like temperature.

205. (A) Both A and R are true and R is the correct explanation of A.
Cascade control is highly effective at neutralizing supply disturbances. By isolating the disturbance within the fast inner loop, the slave controller detects and corrects variations immediately. This rapid local correction occurs well before the disturbance has a chance to propagate through the process and cause deviations in the primary outer variable.

206. (C) Controlling temperature using both a heating valve and cooling valve.
A classic industrial application of split-range control is temperature regulation inside a chemical reactor using both heating and cooling media. A single temperature controller adjusts two separate valves, opening the heating valve during low output demands and transitioning to open the cooling valve when the controller output increases.

207. (D) Tune the slave first with master in manual, then tune the master.
Tuning a cascade control system must always follow a specific sequential procedure. The inner slave controller is tuned first while the outer master controller remains in manual mode. Once the fast inner loop is stabilized and performing well, the master loop is closed and tuned to regulate the primary variable.

208. (B) III only
The statement claiming that cascade control decreases the overall response speed of the system is incorrect. By adding an inner feedback loop that quickly rejects localized disturbances, cascade control actually improves and accelerates the overall dynamic response of the system, preventing slower oscillations from developing in the outer loop.

NODIA

209. (B) P-2, Q-3, R-1, S-4
Each control architecture features unique physical layouts. Single-loop control drives a single valve using one output. Cascade control routes the master controller output to define the slave setpoint. Split-range control uses one controller to operate multiple valves, while feed-forward control incorporates preemptive input signals measured directly from external disturbance sensors.

210. (D) Both valves are fully closed.
In a split-range setup where the heating valve closes from three to nine psi and the cooling valve opens from nine to fifteen psi, a controller output of exactly nine psi represents the transition point. At this specific value, both valves are closed, preventing heating and cooling media from flowing simultaneously.

211. (A) Adjust their own tuning parameters in real-time as dynamics change
Adaptive control algorithms are characterized by their ability to automatically adjust their tuning parameters in real-time. This dynamic adjustment allows the controller to maintain optimal closed loop performance despite significant changes in process gains, time constants, or environmental conditions, preventing the deterioration often experienced with fixed gain controllers.

212. (C) Model reference adaptive control
Model reference adaptive control is a prominent subclass of adaptive systems. It uses an explicit

that works against the mechanical tension of the return spring. As the spring compresses, the actuator stem moves upward, opening the valve and allowing process fluid flow.

233. (D) The absolute lack of compressed air infrastructure in remote installations
Electric motor actuators are highly favored in remote installations where a compressed air utility is unavailable. Installing and maintaining air compressors in isolated locations is economically unfeasible. In these scenarios, electric actuators provide a reliable means of control, operating directly from local power lines or battery systems.

234. (A) The actuator must overcome unbalanced fluid forces and packing friction.
Sizing a pneumatic actuator requires calculating the force needed to stroke the valve under design conditions. The actuator must generate sufficient thrust to overcome internal packing friction and the unbalanced dynamic forces exerted by the process fluid on the valve plug, ensuring reliable movement across the full signal range.

235. (A) Both A and R are true and R is the correct explanation of A.
Pneumatic spring-diaphragm actuators remain the chemical industry standard because of their mechanical simplicity and intrinsic safety. Unlike electric actuators, they do not present an ignition risk in explosive environments. Additionally, the built-in return spring provides a highly reliable mechanical fail-safe position if control air pressure is lost.

236. (B) $F =$ Pressure $\times$ Diaphragm Area
The mechanical force generated by a pneumatic diaphragm actuator is mathematically defined as the product of the applied control air pressure and the effective surface area of the diaphragm. This calculation determines the initial thrust available to compress the return spring and overcome opposing frictional forces within the valve.

237. (A) They lack simple, mechanical spring-driven fail-safe action.
A major disadvantage of conventional electric actuators is the lack of simple, spring-driven fail-safe mechanisms. While pneumatic actuators use robust mechanical springs to force the valve closed or open on power loss, electric actuators typically require backup batteries or complex electronic systems to achieve a safe shutdown state.

238. (A) I and II
Fail-safe design is determined strictly by the safety requirements of the process. For an exothermic reactor, a cooling water valve must fail open to prevent dangerous overheating. Conversely, a fuel gas valve must fail closed on power loss to prevent fuel from accumulating, avoiding potential fires or explosions.

239. (D) P-2, Q-1, R-4, S-3
Different actuator types possess distinct mechanical characteristics. Spring-diaphragm units offer simple fail-safe operation using standard signals. Pneumatic pistons generate high thrust for long strokes using high-pressure air. Electric motors utilize geared drives that depend on power, while electro-hydraulic actuators deliver massive force and stiffness via internal fluid pumps.

240. (C) The pressure range needed to stroke the valve fully with no process pressure
The bench set of a pneumatic actuator is defined as the specific air pressure range required to stroke the valve fully when there are no process fluid forces acting on the plug. This value is measured on the test bench and helps verify that the spring is properly calibrated before installation.

241. (B) Constant differential pressure across the valve itself
The inherent flow characteristic of a control valve is the relationship between the flow rate and the valve stem travel under the specific condition of a constant differential pressure across the valve. This standardized factory test isolates the valve dynamics from the variable pressure drops found in piping systems.

242. (D) Equal percentage changes in the existing flow rate
An equal percentage flow characteristic means that equal increments of valve stem travel produce equal percentage changes in the existing flow rate. Consequently, at small openings, the absolute flow change is very small, while at larger openings, the same step change in travel produces a much larger absolute change in flow.

Click Here to Buy book on Amazon

NQDIA

222. (C) An electromagnetic coil acting on a flapper-nozzle assembly
The physical conversion mechanism inside an I/P converter is based on an electromagnetic coil acting on a flapper-nozzle assembly. As the electrical current changes, the coil varies the magnetic force on the flapper, altering its distance from the nozzle. This movement restricts nozzle exhaust, producing a proportional pneumatic output pressure.

223. (D) To make the physical stem position match the controller command
The primary operational role of a control valve positioner is to ensure that the physical position of the valve stem matches the command signal from the controller. It continuously measures the stem position and adjusts the pneumatic air pressure to overcome friction, stiction, and process fluid forces.

224. (C) Iteratively adjusting zero and span maps the input range to full travel
Calibrating a control valve positioner involves mapping the electrical input signal range directly to the full mechanical travel of the valve stem. This calibration is achieved by iteratively adjusting the zero and span settings, ensuring that the valve is fully closed and fully open at the signal limits.

225. (A) Both A and R are true and R is the correct explanation of A.
A control valve positioner acts as a secondary closed loop controller. It receives the control signal as its setpoint and uses mechanical feedback to monitor stem position. By continuously adjusting the pneumatic air pressure, it ensures the stem reaches the targeted position, effectively counteracting external process forces.

226. (D) When the valve faces high differential pressure or packing friction
A valve positioner is highly recommended when the control valve operates under under high differential pressure or experiences significant packing friction. These forces can cause the stem to stick or lag behind. The positioner detects these deviations and increases air pressure to force the valve stem to the correct position.

227. (B) 9 psi
An input of twelve milliamperes represents exactly fifty percent of the standard four to twenty milliampere range. For an I/P converter calibrated to output a standard three to fifteen pounds per square inch signal, fifty percent of this range corresponds to exactly nine pounds per square inch of pneumatic pressure.

228. (B) II only
The statement asserting that positioners alter the inherent flow characteristic of the valve is incorrect. The inherent flow characteristic is determined strictly by the physical shape of the internal valve plug and seat. The positioner simply ensures accurate stem positioning, mitigating hysteresis and deadband without changing this mechanical design.

229. (A) P-2, Q-1, R-4, S-3
Each component within a control valve assembly serves a specific function. The I/P converter translates standard current signals to proportional pneumatic pressures. The positioner ensures the stem reaches the commanded position. The flapper-nozzle assembly converts small mechanical movements into pressure changes, and the actuator spring provides critical fail-safe mechanical action.

230. (D) It uses microprocessors and digital protocols for diagnostics.
A smart positioner is distinguished by its use of microprocessors and digital communication protocols like HART or Foundation Fieldbus. This digital integration allows for advanced diagnostics, online self-calibration, and remote configuration, offering significant maintenance advantages over traditional pneumatic positioners that rely entirely on mechanical linkages and pneumatic relays.

231. (B) A flexible diaphragm, heavy return spring, and actuator stem
The primary mechanical components of a standard pneumatic spring-diaphragm actuator are a flexible diaphragm, a heavy return spring, and an actuator stem. When control air pressure is applied to the diaphragm, it generates a force that compresses the spring, moving the stem to adjust the internal valve position.

232. (C) Move against spring tension to open the valve
In an air-to-open pneumatic actuator, increasing the control air pressure acts directly on the flexible diaphragm. This pressure creates a force

CHAPTER 04
Data Acquisition Systems

2010

1. Which of the following best defines a continuous-time analog signal in the context of Data Acquisition Systems?
(A) A signal having a continuous range of values at every instant of time
(B) A signal being quantized in both the time domain and amplitude domain
(C) A signal defined at discrete time steps with continuous analog amplitude
(D) A signal restricted to taking only a set of discrete voltage levels

2021

2. In basic signal conditioning, an anti-aliasing filter placed before an ADC is typically of which type?
(A) High-pass filter
(B) Band-pass filter
(C) Low-pass filter
(D) Band-stop filter

2016

3. What is the primary function of a signal conditioning amplifier in a generalized PC-based DAS?
(A) To match source impedance and scale sensor signals for the analog-to-digital converter
(B) To perform digital-to-analog conversion and reconstruct the processed wave output
(C) To store real-time acquired measurement data within a local non-volatile memory bank
(D) To provide a high-frequency sampling clock signal for the analog multiplexer stage

2017

4. In a hybrid Data Acquisition System, which component primarily dictates the maximum overall throughput rate?
(A) The stabilization delay and transient response of the main power supply system
(B) The propagation delay of the optocouplers in the digital isolation barrier
(C) The storage capacity and access speed of the intermediate RAM memory buffer
(D) The slowest conversion element, typically the ADC or the multiplexer settling time

2019

5. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In a multiplexed Data Acquisition System, capacitive coupling between adjacent channels can lead to measurement errors.
Reason (R): Crosstalk occurs when a portion of a signal on one channel is inadvertently transferred to another channel.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009

6. The settling time of an analog multiplexer is defined as the time required for the output to:
(A) Transition completely from the maximum high logic state to the minimum low logic state
(B) Dissipate thermal noise and high-frequency switching transients generated on the bus
(C) Reach and remain within a specified error band of its final value after a channel change
(D) Synchronize its internal clock phases perfectly with the external master clock signal

2005

7. Which parameter of a Sample and Hold (S/H) circuit specifies the time required for the hold capacitor to charge to the new input voltage level?
(A) Aperture delay
(B) Droop rate
(C) Aperture jitter
(D) Acquisition time

2014

8. In a Sample and Hold circuit, a high droop rate is primarily caused by:
(A) High leakage current of the hold capacitor or

Downloaded from www.pdf.tube

243. (A) 1 psi
The flow coefficient is a standardized measure of valve capacity. It represents the volume of water in US gallons per minute that will flow through a fully open valve at sixty degrees Fahrenheit with a pressure drop of exactly one pound per square inch across the valve body.

244. (C) They reflect actual flow versus travel under variable system pressure drops.
The installed flow characteristic represents the actual relationship between valve travel and flow rate when the valve is operating in a physical piping system. Unlike the inherent characteristic, it accounts for variable line losses and system pressure drops that occur as the flow rate changes during operation.

245. (A) Both A and R are true and R is the correct explanation of A.
An equal percentage valve is typically chosen for piping systems with high line losses. As the flow increases, the pressure drop across the valve decreases. The non-linear equal percentage inherent curve compensates for this drop, yielding an installed characteristic that is nearly linear, which helps maintain stable loop gain.

246. (D) Vapor pressure
Cavitation in a liquid control valve occurs when the local pressure drops below the vapor pressure of the fluid at the operating temperature. This pressure drop causes vapor bubbles to form. As the pressure recovers downstream, these bubbles collapse violently, generating micro-jets that damage the internal metal surfaces of the valve.

247. (B) In flashing, downstream pressure stays below the fluid's vapor pressure.
The primary difference between flashing and cavitation is the behavior of downstream pressure. In flashing, the pressure downstream of the valve remains below the vapor pressure of the fluid, so the vapor phase persists. In cavitation, the downstream pressure recovers above the vapor pressure, causing the bubbles to collapse.

248. (A) I and II
Liquid valve sizing equations depend heavily on fluid specific gravity. During severe cavitation or flashing, choked flow conditions can occur where the fluid velocity reaches a physical limit. Once choked, decreasing the downstream pressure further will not increase the volumetric flow rate through the valve body, representing a hard sizing limit.

NODIA

249. (D) P-1, Q-2, R-3, S-4
Each valve characteristic exhibits unique mathematical properties. A linear characteristic has a constant change in flow with travel. An equal percentage characteristic has a change in flow proportional to flow. Quick-opening valves reach maximum flow at low travel, and installed characteristics shift away from inherent due to system line losses.

250. (A) Internal valve trim due to collapsing vapor bubbles
Severe cavitation damage primarily impacts the internal valve trim, including the plug, seat, and cage. This damage is caused by the violent collapse of vapor bubbles as pressure recovers. The resulting high-energy micro-jets create localized pitting and erosion, giving the metal a characteristic sand-blasted appearance and compromising shutoff.

251. (B) The critical pressure drop ratio (x_T)
In compressible gas valve sizing, predicting choked flow conditions requires evaluating the critical pressure drop ratio. This parameter represents the ratio of pressure drop to absolute inlet pressure at which the gas velocity reaches sonic speed at the vena contracta, limiting any further increase in mass flow rate.

252. (B) Multi-stage trims that drop pressure gradually in steps
To prevent or mitigate cavitation damage, engineers frequently use multi-stage trims. These specialized trims force the fluid to flow through a series of restriction stages, dropping the pressure gradually. This step-by-step reduction ensures that the local pressure never falls below the vapor pressure, preventing bubbles from forming.

253. (A) The valve pressure drop remains relatively constant across all flow rates
A linear inherent valve characteristic is recommended when the pressure drop across the valve remains relatively constant across all operating flow rates. Under this condition, the installed characteristic will match the inherent linear characteristic, ensuring that the control loop gain remains stable and predictable across the entire operating range.

mathematical model that defines the desired closed loop performance. The controller continuously adjusts its own parameters to force the actual process output to track the reference model output as closely as possible, ensuring consistent dynamics.

213. (A) Predicting future plant behavior and solving an optimization online
Model Predictive Control optimizes control actions by utilizing an explicit dynamic model of the process to predict future behavior over a specified time horizon. At each control interval, the controller solves an online optimization problem to calculate the optimal sequence of future control movements, executing only the first step.

214. (D) It accounts for interactions between pressure, level, and fuel flows.
Multivariable control systems in power plants are designed to manage the strong coupling that exists among critical boiler variables. By explicitly accounting for interactions between steam pressure, drum level, and fuel flow rates, these controllers optimize overall plant efficiency and prevent the unstable oscillations caused by single-loop control interactions.

215. (A) Both A and R are true and R is the correct explanation of A.
Adaptive control is highly beneficial for non-linear or time-varying processes. By continuously estimating the changing process parameters online, the controller dynamically adjusts its tuning. This ensures that the system maintains high performance and stability as physical dynamics change, preventing the sluggishness or instability of fixed-gain designs.

216. (C) An online recursive parameter estimation algorithm
A Self-Tuning Regulator relies on an online recursive parameter estimation algorithm running continuously in the background. This algorithm monitors the input and output signals of the process to estimate the coefficients of the transfer function. The regulator then uses these updated estimates to recalculate the controller settings.

217. (D) 'Shrink and Swell' effects in the drum level during pressure transients
The non-linear shrink and swell effects in boiler steam drums present a major operational challenge. During sudden pressure drops, steam bubbles expand, causing the drum level to rise temporarily despite a decrease in liquid inventory. Multivariable control handles this interaction, preventing inappropriate feedwater adjustments that compromise boiler safety.

218. (A) I and III
Gain scheduling is an effective adaptive method that adjusts parameters based on measured operating conditions. However, adaptive control systems are mathematically complex and require high computational resources. Unlike simpler fixed PID controllers, these advanced algorithms demand online estimation routines, making their implementation and validation more challenging in industrial plants.

219. (B) P-2, Q-1, R-4, S-3
Advanced control strategies use different core mechanisms. Model Predictive Control optimizes future trajectories over a defined horizon. Model Reference Adaptive Control forces the plant to match an ideal reference model. Gain scheduling switches parameters based on measured load regions, while decoupling mathematically eliminates interactions between control channels.

220. (B) The lack of robust stability proofs during extreme transients
A major barrier to applying adaptive control in highly critical operations is the difficulty in mathematically proving stability under all transient conditions. During rapid, unexpected upsets, recursive estimation algorithms can diverge or adapt incorrectly, potentially causing unstable control actions that compromise safety in nuclear or high-pressure plants.

221. (A) 4-20 mA electrical signals to 3-15 psi pneumatic signals
A Current-to-Pneumatic converter is an essential interface device used in process industries. It translates standard analog four to twenty milliampere electrical control signals from the computer into proportional three to fifteen pounds per square inch pneumatic signals, which are then used to position traditional pneumatic control valve actuators.

Click Here to Buy book on Flipkart

265. (A) Both A and R are true and R is the correct explanation of A.
Butterfly valves are typically not recommended for precise flow control at small openings. At low opening angles, the high dynamic torque exerted by the process fluid on the disc combined with high flow sensitivity to small angular movements can lead to unstable control actions and poor valve positioning accuracy.

266. (A) Permissible leakage rate when fully closed
The required shutoff class of a control valve is determined by the maximum permissible leakage rate when the valve is fully closed under design differential pressure. These standardized classes, such as ANSI Class IV and Class VI, define the testing procedures and maximum allowable leak rates for different applications.

267. (A) I and II
Choked flow occurs when the velocity of the fluid at the vena contracta reaches sonic velocity for gases or causes severe vaporization for liquids. Under choked conditions, the mass flow rate reaches its absolute maximum limit, and further decreasing the downstream pressure will not increase the flow rate through the valve.

268. (B) P-1, Q-2, R-3, S-4
Various fluid dynamics terms are essential in control valve sizing. The vena contracta is the point of lowest pressure and highest velocity. The liquid recovery factor determines the likelihood of cavitation. Specific gravity represents the fluid density relative to water, and the expansion factor adjusts for gas density changes.

269. (A) The ratio of pressure drop across the valve to vena contracta drop
The liquid pressure recovery factor is a dimensionless parameter that measures the ability of a control valve to recover pressure downstream of the vena contracta. It is defined as the square root of the ratio of the net pressure drop across the valve to the pressure drop at the vena contracta.

270. (C) Valve pressure drop decreases as flow increases due to line losses.
In a long piping network, line losses increase dramatically with flow rate, which causes the pressure drop available across the control valve to decrease. This shifting pressure drop alters the valve's installed characteristic, making an inherently non-linear equal percentage valve behave in a nearly linear fashion when operating within the system.

****

Downloaded from www.pdf.tube

254. (C) A higher C_v indicates a more restrictive, smaller valve.
The statement asserting that a higher flow coefficient indicates a more restrictive, smaller valve is incorrect. The flow coefficient is a direct measure of valve capacity. Therefore, a larger coefficient indicates a less restrictive, larger internal path that permits a higher volumetric flow rate for a given pressure drop.

255. (A) Both A and R are true and R is the correct explanation of A.
Sizing a control valve to operate fully open at the exact maximum anticipated flow rate is poor engineering practice. This approach leaves no safety margin for unexpected surges. Standard practice dictates sizing the valve so that the maximum design flow occurs at seventy to eighty percent of total travel.

256. (C) Increases significantly due to vapor expansion
When a liquid flashes inside a control valve, some of the liquid transitions into vapor because downstream pressure remains below vapor pressure. Since vapor has a much lower density than liquid, the volumetric flow rate exiting the valve increases significantly, requiring larger downstream pipe diameters to prevent excessive velocity.

257. (B) Vapor pressure
The vapor pressure of a fluid at its operating temperature is the key physical property that dictates its susceptibility to flashing and cavitation. If the local pressure inside the valve drops below this threshold, the liquid will begin to vaporize, initiating the bubbles that lead to cavitation or flashing.

258. (A) I and II
Multi-stage valve trims are specifically designed to prevent cavitation by ensuring that the local pressure at each stage remains strictly above the vapor pressure of the liquid. By distributing the pressure drop over multiple restrictions, they also reduce velocity, which significantly decreases the overall noise and vibration generated by the valve.

259. (A) P-1, Q-2, R-3, S-4
Each harsh process phenomenon requires a specific valve trim or body countermeasure. High pressure drop liquids use anti-cavitation trim. Flashing requires hardened materials and a swept-angle body. High noise gas flows are mitigated using multi-hole aerodynamic trims, and sticky or viscous fluids are best controlled using eccentric rotary or ball valves.

NODIA

260. (C) The ratio of maximum to minimum controllable flow
The rangeability of a control valve is the mathematical ratio of the maximum controllable flow to the minimum controllable flow. It defines the operational flow span over which the valve maintains its specified flow characteristic, indicating the valve's capability to regulate flow accurately under wide process load variations.

261. (C) 20 gpm
Rangeability is the ratio of maximum flow to minimum controllable flow. Given a maximum flow rate of one thousand gallons per minute and a rangeability of fifty, the minimum controllable flow is calculated by dividing one thousand by fifty, which mathematically yields exactly twenty gallons per minute of fluid flow.

262. (D) Full-port ball valve
A full-port ball valve offers the highest flow coefficient for a given nominal pipe size because its open position provides an unobstructed circular path. This straight-through design minimizes flow restriction and pressure drop, yielding a significantly higher flow capacity compared to more tortuous flow paths like globe or angle valves.

263. (B) Packing friction and mechanical linkage backlash
Dead-band in a control valve is primarily caused by mechanical friction in the stem packing and backlash in the actuator linkages. These forces prevent the stem from moving until the control signal change is large enough to overcome the static friction, resulting in a temporary lag in valve response.

264. (C) Trim includes all the wetted parts that dictate flow characteristic and shutoff capability (plug, seat, stem).
The trim of a control valve refers to the collection of wetted internal components that come into direct contact with the process fluid. This assembly includes the plug, seat ring, cage, and stem. These components dictate the inherent flow characteristic of the valve and define its tight shutoff capability.

output buffer amplifier
(B) High dielectric absorption occurring within the physical hold capacitor
(C) Low leakage current through the semiconductor junction of the hold switch
(D) High input impedance designed into the modern CMOS output buffer amplifier

2017
9. For an 8-bit Digital-to-Analog Converter (DAC) with a full-scale range of 5 V, what is the approximate size of the Least Significant Bit (LSB)?
(A) 4.88 mV
(B) 9.76 mV
(C) 19.53 mV
(D) 39.06 mV

2014
10. Match the following DAC specifications (List-I) with their definitions (List-II).
List I: DAC specifications
P. Resolution
Q. Full-scale voltage
R. Settling time
S. Accuracy
List II: Definitions
1. Maximum output voltage possible
2. Closeness of the output to the ideal theoretical value
3. Time taken to reach final value within a specific band
4. Number of distinct analog levels that can be produced
(A) P-4, Q-1, R-3, S-2
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-2, R-3, S-1
(D) P-3, Q-1, R-4, S-2

2024
11. Which of the following is a primary disadvantage of a weighted-resistor DAC architecture?
(A) Requires a wide range of precision resistor values for high-resolution configurations
(B) Requires an excessive number of analog switches that complicate the control logic
(C) Has a very slow settling time and conversion rate compared to basic serial architectures
(D) Requires only two distinct resistor values which complicates fabrication processes

2023
12. The R-2R ladder DAC architecture requires how many distinct resistor values?
(A) One
(B) Two
(C) Four
(D) Eight

2005
13. According to the Nyquist criterion, to prevent aliasing, the sampling frequency must be:
(A) Exactly equal to the highest frequency component present in the input signal
(B) At least half of the highest frequency component present in the input signal
(C) Exactly twice the transition bandwidth of the front-end analog reconstruction filter
(D) Greater than twice the highest frequency component present in the input signal

2019
14. What is the fundamental cause of quantization error in an Analog-to-Digital Converter?
(A) The continuous nature of the time axis which introduces jitter into sampling points
(B) The high-frequency thermal noise generated in the internal comparator circuit arrays
(C) The mapping of a continuous range of analog values to discrete digital codes
(D) To provide a high-frequency sampling clock signal for the analog multiplexer stage

2024
15. Consider the following statements regarding ADC specifications:
I. Conversion time limits the maximum throughput rate.
II. Missing codes occur when an ADC cannot output certain digital values.
III. DNL measures the deviation of the actual transfer function from a straight line.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2001
16. If an ADC exhibits severe Differential Non-Linearity (DNL), which of the following errors is most likely to occur?
(A) Aliasing of high-frequency signals
(B) Increased aperture jitter
(C) Reduction in the input voltage range
(D) Missing codes in the digital output

2004
17. Which Analog-to-Digital Converter architecture provides the fastest conversion speed?
(A) Flash (parallel)

Click Here to Buy book on Amazon

(B) Successive Approximation Register (SAR)
(C) Dual-slope integrating
(D) Sigma-Delta

2012
18. A Dual-slope ADC is highly preferred for applications requiring:
(A) Ultra-high speed transient data capture and high-frequency waveform analysis
(B) Direct, real-time down-conversion and digital processing of RF band signals
(C) High resolution and excellent rejection of power-line electromagnetic noise
(D) Minimal passive and active component count designed for video digitization

2022
19. Sigma-Delta ADCs achieve high resolution primarily through which two mechanisms?
(A) Oversampling and noise shaping
(B) R-2R ladders and flash comparators
(C) Undersampling and analog filtering
(D) Successive approximation and dual integration

2013
20. Consider the following statements regarding Sigma-Delta ADCs:
I. They employ an oversampling ratio significantly greater than one.
II. Decimation filters are used to reduce the sampling rate digitally.
III. They are typically used for high-speed RF sampling.
IV. Noise shaping pushes quantization noise to higher frequencies.
Which of the above statements are correct?
(A) I, II and III
(B) I, II and IV
(C) II, III and IV
(D) I and IV

2013
21. Monolithic ADCs differ from hybrid ADCs primarily in that monolithic ADCs:
(A) Consist of multiple distinct ICs packaged together
(B) Are fabricated on a single silicon chip
(C) Cannot include on-chip voltage references
(D) Require manual laser trimming of external components

2015
22. In the thermal management of hybrid ADC packaging, what is a primary concern not typically found in low-resolution monolithic types?
(A) Managing dielectric absorption and capacitive leakage in standard digital isolator chips
(B) The necessity of high-capacity liquid cooling loops to dissipate internal heat generation
(C) Thermal gradients causing thermoelectric voltages and drift between internal components
(D) Crosstalk and parasitic inductive coupling between adjacent pins of the device leadframe

2024
23. Error budget analysis in a DAS aggregates various uncertainties. Which of the following is considered a static error?
(A) Aperture jitter
(B) Settling time error
(C) Crosstalk
(D) Offset error

2016
24. How is the total Root Sum Square (RSS) uncertainty calculated from uncorrelated error sources E_1, E_2, ..., E_n?
(A) Square root of the sum of the squares of individual errors
(B) Direct algebraic summation of all isolated individual errors
(C) Mathematical average of the absolute values of all errors
(D) Multiplying product of the magnitudes of all unique errors

NODIA

2023
25. Consider the following statements regarding noise reduction techniques:
I. Shielding minimizes capacitive coupling of noise.
II. Ground loops can be eliminated by connecting grounds at multiple points.
III. Differential inputs reject common-mode noise.
IV. Galvanic isolation allows DC current flow between circuits.
V. Twisted pair cables reduce inductive interference.
Which of the above statements are INCORRECT?
(A) II, III and V
(B) II and IV
(C) I, III and V
(D) I, IV and V

2008

26. Galvanic isolation in a DAS is primarily utilized to:
(A) Increase the analog input bandwidth of pre-amplification and sampling stages
(B) Break ground loops and protect equipment from high common-mode voltages
(C) Reduce the quantization error and integral non-linearity of the main ADC
(D) Improve the settling time and reduce dynamic crosstalk of the multiplexer

2024

27. What is the primary purpose of a Programmable Gain Amplifier (PGA) in a DAS?
(A) To optimize the input signal amplitude to match the ADC full-scale range
(B) To convert unipolar analog signals to symmetric bipolar voltage signals
(C) To filter out high-frequency electromagnetic noise dynamically in real-time
(D) To provide high-voltage galvanic isolation between system ground planes

2008

28. A unipolar analog input range of 0 to 10 V is converted by a 12-bit ADC. What is the hexadecimal code for an input of 5 V, assuming ideal characteristics?
(A) 0x3FF
(B) 0x7FF
(C) 0x800
(D) 0xFFF

2008

29. Hardware triggering in a DAS is preferred over software triggering when:
(A) The acquisition system must be triggered manually by a specific user keyboard input
(B) The overall data logging rate is set to be extremely slow and non-time-critical
(C) The trigger condition depends on executing a highly complex software loop algorithm
(D) Precise timing and synchronization with an external event are strictly required

2005

30. Choose the correct sequence of operations in a standard multiplexed DAS acquiring a single channel.
(A) Sample/Hold → Amplification → Channel Selection → A/D Conversion
(B) A/D Conversion → Channel Selection → Amplification → Sample/Hold
(C) Channel Selection → Amplification → Sample/Hold → A/D Conversion
(D) Amplification → Channel Selection → A/D Conversion → Sample/Hold

2011

31. Counter/timer chips in a DAS are most typically used for:
(A) Storing digitized voltage values inside local high-capacity RAM buffers
(B) Generating precise sampling rates and measuring external signal pulse widths
(C) Providing stable reference voltages to the internal digital-to-analog converter
(D) Converting incoming serial data streams directly into parallel output formats

2010

32. In the context of Data Acquisition Virtual Instruments (VIs), what does the software primarily replace?
(A) The physical ADC hardware and its associated signal conditioning pre-amplifiers
(B) The physical sensors and transducers used to measure real-world parameters
(C) The physical multiplexer switches that route multiple separate input channels
(D) Traditional hardware front-panels and dedicated data processing modules

2011

33. Standalone data loggers typically differ from PC-based DAS by having:
(A) Internal memory, independent power, and autonomous operation capabilities
(B) Higher reliance on an active host PC processor for continuous monitoring
(C) Only digital input capabilities without any analog input options
(D) A direct dependency on high-speed parallel buses for communication

2019

34. PCMCIA cards were historically used in distributed data loggers primarily for:
(A) High-speed analog active filtering
(B) Providing isolated power supply lines
(C) Expanding non-volatile memory storage
(D) Performing real-time hardware triggering

2010

35. Consider the following RS-232C signals:
I. DTR (Data Terminal Ready)
II. RTS (Request to Send)
III. CTS (Clear to Send)
IV. TXD (Data Transmission)
Which of the following represents the correct sequence in which they are typically asserted

Downloaded from www.pdf.tube

during a hardware handshake?
(A) I, II, III, IV
(B) II, I, IV, III
(C) I, III, II, IV
(D) II, III, I, IV

2019
36. In the RS-232C standard, a logic '1' (Mark) is represented by a voltage level of:
(A) -3 V to -15 V
(B) 0 V
(C) 0 V to 5 V
(D) +3 V to +15 V

2005
37. Which of the following is a key advantage of RS-485 over RS-232C?
(A) RS-485 uses single-ended signaling
(B) RS-485 supports multi-drop network topologies
(C) RS-485 is strictly full-duplex on two wires
(D) RS-485 requires lower-cost terminating connectors than RS-232C

2021
38. Impedance matching in an RS-485 network is achieved by placing termination resistors:
(A) At every active and passive node connected on the network
(B) At the transmitter node of the master controller
(C) At the two physical ends of the differential transmission line
(D) In series with the differential driver transmitter outputs

2024
39. Ethernet integration in remote data logging relies on TCP/IP. What is a common bottleneck in such high-speed systems?
(A) The physical characteristic impedance mismatch of standard BNC input connectors
(B) The fundamental inability of Ethernet physical layers to transmit digital data
(C) The short distance limitation of high-speed multi-mode fiber optic cable runs
(D) Protocol overhead and network latency affecting strict real-time determinism

2003
40. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Ethernet networks based on standard TCP/IP are not inherently suited for strict real-time deterministic data acquisition.
Reason (R): TCP/IP incorporates variable routing delays and packet retransmissions which introduce unpredictable timing jitter.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2002
41. The IEEE 488 (GPIB) bus consists of how many total signal lines?
(A) 8
(B) 16
(C) 24
(D) 32

2003
42. In an IEEE 488 (GPIB) setup, a device that is configured to transmit data onto the bus is a:
(A) Listener
(B) Talker
(C) Controller
(D) Poller

2004
43. The 3-wire handshake mechanism in the IEEE 488.2 protocol utilizes which three lines?
(A) DAV, NRFD, NDAC
(B) ATN, SRQ, EOI
(C) TXD, RXD, GND
(D) REN, IFC, SRQ

2023
44. What does SCPI stand for in instrument control protocols?
(A) Serial Control Protocol for PC-based Instruments
(B) System Code Architecture for Parallel Interfaces
(C) Standard Commands for Programmable Instruments
(D) Synchronous Communication for Peripheral Instruments

NODIA

2003
45. Match the display technologies (List-I) with their operating principles (List-II).
List I: Display technologies
P. Passive Matrix LCD
Q. Active Matrix LCD
R. Plasma Display
S. Projection System
List II: Operating principles
1. Uses a dedicated thin-film transistor for each

pixel
2. Relies on ionized gas emitting UV light to excite phosphors
3. Uses optical lenses to display images on an external screen
4. Uses a simple grid of conductive traces to activate pixels

(A) P-4, Q-1, R-2, S-3
(B) P-1, Q-4, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-4, S-3

2024
46. In Digital Storage Oscilloscopes (DSOs), equivalent-time sampling is primarily used for observing:
(A) Single-shot, transient, non-repetitive signals requiring fast capture
(B) Very low-frequency continuous analog signals with minimal amplitude drift
(C) High-frequency repetitive signals that exceed the real-time sample rate
(D) Direct current signals containing a highly significant offset voltage level

2025
47. The memory depth of a Digital Storage Oscilloscope directly affects its ability to:
(A) Display colors and graphical elements with high color fidelity
(B) Maintain a high sample rate over a long timebase setting
(C) Reject common-mode voltage noise at high frequency ranges
(D) Increase the analog bandwidth of the input pre-amplifier

2018
48. In a swept-tuned spectrum analyzer, the Resolution Bandwidth (RBW) filter determines:
(A) The absolute maximum safe input voltage limit of the RF attenuation stage
(B) The automatic sweep rate and frequency step of the internal local oscillator
(C) The physical horizontal and vertical screen dimensions of the display unit
(D) The ability to resolve closely spaced frequency components in the spectrum

2005
49. FFT-based spectrum analyzers differ from swept-tuned analyzers mainly because they:
(A) Capture time-domain data and mathematically transform it to the frequency domain
(B) Use an internal sweeping local oscillator mixed with incoming intermediate signals
(C) Lack the fundamental capability to measure phase angle and vector information
(D) Are restricted to low-voltage signals with high source impedance

2006
50. Consider the following statements about Logic Analyzers:
I. Timing analysis is asynchronous to the system under test.
II. State analysis uses the clock of the system under test.
III. They are used to measure precise analog voltage levels.

Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I

2006
51. A Vector Network Analyzer (VNA) is primarily used to measure:
(A) Both amplitude and phase properties (S-parameters) of high-frequency networks
(B) The digital logic levels and timing relationships of parallel buses
(C) The low-frequency acoustic spectrum of surrounding environmental noise signals
(D) The steady-state operating temperature profile across an active printed circuit

2009
52. Chart recorders have largely been replaced by digital systems because they:
(A) Offer superior high-frequency tracking capabilities compared to digital ADCs
(B) Require no digital-to-analog converter interface
(C) Provide continuous analog storage with high noise immunity
(D) Are limited by mechanical inertia and offer poor long-term data manipulation

2003
53. Which filtering application is most crucial immediately after a digital-to-analog conversion?
(A) Anti-aliasing low-pass filtering
(B) Reconstruction smoothing filtering
(C) Power-line notch band-rejection
(D) High-pass coupling phase filtering

2023
54. An ideal analog multiplexer should have:

Click Here to Buy book on Flipkart

reference voltage source over operating range

2001

109. Which ADC type uses a binary search algorithm to determine the digital output?
(A) Flash ADC
(B) Dual-slope ADC
(C) Sigma-Delta ADC
(D) SAR ADC

2008

110. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Flash ADCs are rarely available in resolutions above 12 bits.
Reason (R): The number of required comparators doubles with every additional bit, causing excessive size and power dissipation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025

111. Dual-slope ADCs inherently reject AC noise (like 50/60 Hz power-line interference) by:
(A) Utilizing sharp digital notch filter algorithms on the raw data output
(B) Setting the integration time to a multiple of the noise wave period
(C) Shielding the comparator stages from external high-frequency RF fields
(D) Using extremely high oversampling ratios coupled with digital filtering

2025

112. The noise shaping characteristic of a Sigma-Delta modulator functions as a:
(A) High-pass filter for both the analog signal and the generated digital quantization noise
(B) Low-pass filter for the quantization noise while keeping high-frequency components intact
(C) Band-pass filter for the input signal that heavily restricts outer frequency components
(D) Low-pass filter for the input signal and high-pass filter for the quantization noise

2004

113. IC implementation of hybrid ADCs typically utilizes multi-chip modules (MCMs). What is an advantage of MCMs?
(A) They allow mixing of different optimized semiconductor technologies (e.g., CMOS and Bipolar) in one package
(B) They are inherently cheaper to manufacture than monolithic ADCs for high-volume consumer markets
(C) They do not require an external reference voltage source
(D) They are physically immune to any thermal drift or relative performance changes over temperature

2009

114. Gain error in a DAS measurement channel manifests as:
(A) A constant static voltage offset added uniformly across all output readings
(B) A random high-frequency noise fluctuation between consecutive signal readings
(C) A deviation that is proportional to the input signal amplitude range
(D) Missing codes appearing abruptly within the middle segment of the code range

NODIA

2025

115. Match the hardware noise reduction techniques (List-I) with their functional principle (List-II).
List I: Hardware noise reduction techniques
P. Twisted pair wiring
Q. Optical isolation
R. Differential signaling
S. Shielding
List II: Functional principles
1. Prevents electrostatic coupling from adjacent noise sources
2. Cancels induced magnetic interference by physical geometry
3. Breaks direct electrical connections while transferring signals
4. Subtracts common-mode noise present on two lines
(A) P-2, Q-3, R-4, S-1
(B) P-1, Q-4, R-3, S-2
(C) P-3, Q-2, R-4, S-1
(D) P-2, Q-1, R-4, S-3

2021

116. When analyzing the error budget, the Root Sum Square (RSS) method assumes that the individual error sources are:
(A) Perfectly correlated and linearly dependent across all operational conditions
(B) All deterministic, predictable, and additive in a worst-case scenario manner
(C) Ignored when compiling the overall system error budget

2010

64. Flash ADCs use a resistor divider network. For an N-bit flash ADC, how many comparators are required?
(A) N
(B) N^2
(C) $2^N - 1$
(D) 2^N

2019

65. Choose the correct sequence of filtering stages in a Sigma-Delta ADC processing an analog signal.
(A) Decimation Filter → Anti-aliasing Filter → Integrator
(B) Anti-aliasing Filter → Integrator → Decimation Filter
(C) Integrator → Anti-aliasing Filter → Decimation Filter
(D) Decimation Filter → Integrator → Anti-aliasing Filter

2001

66. Oversampling in a Sigma-Delta ADC improves the Signal-to-Noise Ratio (SNR) because:
(A) The fundamental signal frequency is digitally down-converted and scaled down
(B) The analog comparator network physically generates far less thermal white noise
(C) Quantization noise power is spread over a wider frequency band in the spectrum
(D) It physically prevents dielectric absorption inside the sampling hold capacitor

2008

67. Decimation in a Sigma-Delta ADC involves:
(A) Decreasing the sampling rate while increasing the bit resolution digitally
(B) Increasing the absolute input range of the analog voltage measurement stages
(C) Splitting the digital data stream into ten separate parallel routing lines
(D) Converting the output word back to an analog form via reconstruction paths

2014

68. Thermal drift in a hybrid ADC is primarily measured in:
(A) Absolute volts per elapsed second of operation
(B) Transmission bits per second rate of communication
(C) Characteristic ohms per physical meter of cable line
(D) Parts per million per degree Celsius of temperature

2018

69. What is the effect of reference voltage instability in a DAS?
(A) It changes the fundamental sampling frequency clock of the analog-to-digital converter
(B) It causes a direct proportional error in the converted digital output code values
(C) It decreases the absolute input impedance of the front-end analog multiplexer switch
(D) It alters the logic states of the digital input and output lines on the system bus

2023

70. Consider the following error sources in a Data Acquisition System (DAS):
I. Sensor non-linearity
II. Cable ground loop interference
III. Amplifier offset drift
IV. ADC quantization error
Which of the following represents the correct sequence of these error sources from their origin at the sensor to the digital output?
(A) I, II, III, IV
(B) II, I, IV, III
(C) I, III, II, IV
(D) III, II, I, IV

2017

71. Shielding in data acquisition cables is most effective against:
(A) Low-frequency magnetic fields generated by power transformers
(B) Internal quantization noise generated by the analog-to-digital step
(C) Droop rate leakage inside the sample and hold storage capacitor
(D) High-frequency capacitive coupling and electrostatic interference

2019

72. A ground loop in a DAS is best avoided by:
(A) Grounding the system at a single common point
(B) Grounding the shield at both ends of the cable
(C) Using high-resistance analog signal lines
(D) Removing all shielding jackets from the cables

2005

73. Differential input topologies in a DAS are advantageous over single-ended inputs because they:
(A) Require fewer physical interconnect wires per measuring channel

NODIA

(B) Reject common-mode voltages appearing on both input lines simultaneously
(C) Increase the absolute maximum analog input voltage limit by a factor of ten
(D) Eliminate the need for input signal conditioning amplification

2024
74. Which specification limits the maximum update rate of a DAC in an arbitrary waveform generator?
(A) Input impedance
(B) Settling time
(C) Output voltage range
(D) Dielectric constant of the PCB

2023
75. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Programmable Gain Amplifiers (PGAs) can enhance the dynamic range of a DAS.
Reason (R): PGAs dynamically amplify small signals to match the ADC's full scale, reducing the relative effect of quantization noise.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019
76. In an N-channel analog multiplexer, the term "crosstalk" indicates:
(A) The time it takes to switch from a first active channel to a second active channel
(B) The physical electromagnetic interference between control lines and DC power rails
(C) The unwanted signal coupling from an inactive off-channel to the multiplexer output
(D) The operational failure of a single micro-electronic switch on the silicon die

2006
77. A DAS is configured for bipolar operation. The analog input range is typically:
(A) 0 to +10 V
(B) 4 to 20 mA
(C) 0 to 5 V
(D) -5 V to +5 V

2009
78. Digital I/O lines in a DAS are commonly used for:
(A) Measuring millivolt thermocouple outputs in temperature systems
(B) Filtering high-frequency noise from sensitive analog sensor paths
(C) Controlling external relays and reading physical switch logic states
(D) Performing complex mathematical fast Fourier transforms in real-time

2018
79. When using a counter/timer for frequency measurement, the technique of counting input pulses over a known gating interval is best for:
(A) Very low frequencies
(B) High frequencies
(C) Measuring duty cycle
(D) Phase angle measurement

2021
80. Match the data logger architectures (List-I) with their primary characteristic (List-II).
List I: Data logger architectures
P. PC-based DAS
Q. Standalone Data Logger
R. Distributed Data Logger
S. PCMCIA based Logger
List II: Primary characteristics
1. Relies entirely on host computer's OS and processor
2. Uses networked remote nodes for data collection
3. Highly portable with older form-factor memory card storage
4. Operates autonomously on battery power
(A) P-1, Q-4, R-2, S-3
(B) P-4, Q-1, R-3, S-2
(C) P-1, Q-2, R-4, S-3
(D) P-2, Q-3, R-1, S-4

2007
81. In RS-232C asynchronous data framing, what ensures that the receiver identifies the beginning of a new character?
(A) Start bit
(B) Parity bit
(C) Stop bit
(D) Clock line

2012
82. Which statement best describes the signaling method of the RS-485 standard?
(A) Single-ended, unbalanced voltage
(B) Current loop (4-20mA)

Downloaded from www.pdf.tube

(C) Differential, balanced voltage
(D) Optical pulse width modulation

2010

83. Multi-drop networks using RS-485 require a specific control mechanism. What is it?
(A) A half-duplex arbitration scheme allowing one node to drive the bus at a time
(B) All master and slave transmitters must remain active simultaneously on the bus
(C) The master node uses a separate dedicated transmit line for each unique slave
(D) Carrier-sense multiple access with collision detection (CSMA/CD) implemented on each node

2005

84. In a TCP/IP based remote data acquisition system, UDP is sometimes preferred over TCP when:
(A) 100% guaranteed delivery of every single transmitted packet is strictly mandatory
(B) The communication network exhibits extremely high levels of dynamic packet loss
(C) Encrypting the digital data payload is required for secure industrial telemetry
(D) Minimizing latency is more important than absolute packet reliability and order

2014

85. Consider the following statements concerning the IEEE 488 (GPIB) standard:
I. It utilizes an 8-bit parallel data bus.
II. It allows up to 15 devices to be connected on a single bus.
III. It transmits data exclusively via fiber optics.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) II

2022

86. Which IEEE 488 management line is asserted by the controller to halt all bus activity and initialize devices?
(A) ATN (Attention)
(B) REN (Remote Enable)
(C) IFC (Interface Clear)
(D) SRQ (Service Request)

2010

87. SCPI (Standard Commands for Programmable Instruments) is constructed based on a:
(A) Flat binary protocol defined by unique hexadecimal sequences
(B) Variable-length analog pulse train driven by a timing clock
(C) Proprietary encrypted standard developed by instrument vendors
(D) Hierarchical text-based tree structure defined by standards

2007

88. A passive matrix LCD suffers from slower response times and lower contrast than an active matrix LCD primarily due to:
(A) The lack of a dedicated switching transistor at each pixel structure
(B) The use of active gas plasma cells instead of organic liquid crystals
(C) The relative physical thickness and weight of the glass base substrate
(D) The complete absence of an integrated high-efficiency LED backlight

2011

89. Plasma displays create an image using:
(A) Liquid crystal matrices rotating polarized light according to local electrical field alignments
(B) Tiny pockets of gas that emit ultraviolet light when ionized, which excites phosphors
(C) An analog electron gun scanning beams across a high-voltage phosphor-coated CRT screen
(D) Microscopic moving mirrors fabricated on silicon substrates reflecting external light sources

2007

90. Consider the following statements about Digital Storage Oscilloscopes (DSOs):
I. Real-time sampling digitizes the waveform in a single pass.
II. Memory depth dictates how long the DSO can capture data at a specific sample rate.
III. Advanced triggering can isolate specific digital pulse widths.
IV. They rely exclusively on swept local oscillators.
Which of the above statements are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I and III

NODIA

2012

91. In a DSO, what is the consequence of having a shallow memory depth when setting a slow timebase?

(A) The sample rate must be drastically reduced, risking aliasing
(B) The display illumination level becomes significantly brighter
(C) The physical analog input bandwidth of the channels decreases
(D) The trigger detection function becomes permanently disabled

2025

92. When using a logic analyzer for state analysis, the clock signal is:
(A) Generated internally by the clock circuitry of the logic analyzer
(B) Derived dynamically or randomly from the primary active data lines
(C) Provided externally by the target clock of the system under test
(D) Completely unnecessary for carrying out state analysis operations

2023

93. A Scalar Network Analyzer measures:
(A) Both the complex amplitude and phase response characteristics of the test signal
(B) The phase properties and phase-delay relationships of high-frequency signals
(C) The digital logic levels and timing diagrams of a multi-bus microcontroller unit
(D) The amplitude properties (magnitude) of transmission or reflection signals without phase information

2025

94. Magnetic recorders in legacy instrumentation were primarily used for:
(A) Displaying real-time frequency spectrum plots on a physical laboratory CRT screen
(B) Converting parallel digital bus data structures directly to high speed serial formats
(C) Storing high-bandwidth analog signals for later playback and off-line signal analysis
(D) Powering remote passive sensor elements using magnetic field inductive coupling paths

2019

95. Consider the following statements regarding analog signals and Data Acquisition Systems (DAS):
I. A transducer converts a physical parameter into an electrical signal.
II. Signal conditioning only involves amplification.
III. Filtering is required to restrict signal bandwidth before sampling.
IV. Multiplexing allows one ADC to serve multiple channels.
V. A DAC is always required at the input of a DAS.
Which of the above statements are correct?
(A) I, III and IV
(B) I, II and III
(C) III, IV and V
(D) I, IV and V

2019

96. Which filter parameter is most critical for an anti-aliasing filter to preserve signal phase linearity?
(A) High ripple in the passband
(B) The steepest possible roll-off regardless of phase (e.g., Chebyshev)
(C) Very high insertion loss
(D) A flat group delay response (e.g., Bessel filter)

2006

97. The process by which a multiplexer introduces a transient error voltage into a channel during switching is related to:
(A) Charge injection
(B) Magnetic hysteresis
(C) Thermal runaway
(D) Subsampling

2007

98. In a DAS, if the source impedance of the signal being measured is high, the input impedance of the multiplexer/ADC stage must be:
(A) Strictly equal to the measured source impedance
(B) Significantly lower than the active source impedance
(C) Significantly higher than the active source impedance
(D) Designed to be exactly zero under all load conditions

2004

99. Which architecture is typically considered a hybrid Data Acquisition System?
(A) A system combining a PC, external analog front-end modules, and modular digitizers
(B) A single-chip embedded microcontroller with an integrated, low-resolution internal ADC
(C) A purely physical, mechanical chart recorder drawing traces on moving paper strips
(D) A standalone handheld digital multimeter

Click Here to Buy book on Amazon

measuring voltage and current parameters

2025

100. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In a multiplexed DAS, the acquisition time of the S/H circuit must be accommodated before the ADC begins conversion.
Reason (R): If the ADC converts while the S/H is still in the acquisition phase, it will digitize an unsettled, inaccurate voltage.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025

101. Dielectric absorption in a Sample and Hold circuit is also commonly referred to as:
(A) Dielectric breakdown
(B) Capacitor soakage
(C) Resistive leakage
(D) Piezoelectric effect

2024

102. An aperture time of 1 ns in a S/H circuit implies:
(A) The holding switch circuit retains the analog voltage signal for exactly 1 ns
(B) The sampling semiconductor switch takes exactly 1 ns to transition and fully close
(C) There is a 1 ns timing uncertainty in the actual instant the sample is taken
(D) The analog-to-digital conversion cycle completes in exactly 1 ns of system clock

2010

103. If a 12-bit DAC is replacing an 8-bit DAC operating at the same reference voltage, the resolution becomes:
(A) Unchanged
(B) 4 times finer
(C) 16 times finer
(D) 256 times finer

2016

104. The primary limitation of increasing resolution in an R-2R ladder DAC is:
(A) The strict tolerance and matching requirements of the internal passive resistors
(B) The total number of separate precision reference voltage supplies required on board
(C) The physical trace routing size and complexity of the parallel digital input bus
(D) The maximum achievable operational frequency and speed of the local clock oscillator

2019

105. Match the ADC architectures (List-I) with their primary limitation (List-II).
List I: ADC architectures
P. Flash ADC
Q. SAR ADC
R. Dual-Slope ADC
S. Sigma-Delta ADC
List II: Primary limitations
1. Very slow conversion speed
2. High power consumption and large die area for high resolutions
3. Inherent latency due to digital filtering
4. Speed scales inversely with resolution (requires N clocks)
(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-1, S-3
(C) P-1, Q-4, R-2, S-3
(D) P-2, Q-1, R-4, S-3

2019

106. In an ideal ADC, the quantization error is strictly bounded between:
(A) -1 LSB and +1 LSB
(B) -0.5 LSB and +0.5 LSB
(C) -0.1 LSB and +0.1 LSB
(D) 0 and +1 LSB

2003

107. Throughput rate of an ADC in a continuous sampling DAS is defined as:
(A) The maximum number of complete conversions performed per second
(B) The total duration and time required for one single conversion
(C) The maximum digital data transfer rate on the output serial bus
(D) The average propagation delay of internal digital logic gates

2002

108. Integral Non-Linearity (INL) in an ADC describes:
(A) The step size variation and width deviations occurring between adjacent output codes
(B) The offset voltage error measured at exactly zero volts on the analog input channel
(C) The maximum deviation of the actual transfer function from the ideal straight line
(D) The temperature coefficient and drift of the

NODIA

(A) High ON-resistance and low OFF-resistance
(B) Low ON-resistance and low OFF-resistance
(C) Low ON-resistance and high OFF-resistance
(D) High ON-resistance and high OFF-resistance

2024

55. Consider the following statements concerning Sample and Hold (S/H) circuit specifications:
I. Acquisition time must be less than the sampling period.
II. Aperture time represents the uncertainty in the exact time the switch opens.
III. Dielectric absorption causes the hold capacitor voltage to creep back toward its previous value.
IV. Droop rate is unaffected by temperature.
Which of the above statements are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2011

56. What happens if dielectric absorption is significant in a sample and hold capacitor?
(A) It introduces a memory effect where hold voltage creeps back to a prior state
(B) It permanently damages and shorts the internal switch paths of the capacitor
(C) It minimizes the timing uncertainty during sampling phases
(D) It significantly increases the analog input bandwidth of the sample amplifier

2004

57. A 10-bit DAC has a reference voltage of 10.24 V. What is the value of 1 LSB?
(A) 1 mV
(B) 5 mV
(C) 10 mV
(D) 20 mV

2019

58. The settling time of a DAC is highly dependent on:
(A) The physical layout length of the digital input data trace bus
(B) The internal output amplifier slew rate and parasitic capacitance
(C) The external ambient acoustic noise in the testing environment
(D) The specific parity and start bit framing configuration options

2025

59. Serial DAC architectures (like string DACs) are often chosen for applications requiring:
(A) Minimum pin count and low power
(B) The highest possible conversion speed
(C) High power dissipation
(D) Parallel data processing

2013

60. Consider the following statements regarding ADC errors:
I. INL error cannot be easily calibrated out by simple gain/offset adjustments.
II. Missing codes happen when $DNL > 1$ LSB.
III. Quantization error can be completely eliminated by shielding.
IV. Aliasing occurs if sampling rate is less than twice the maximum signal frequency.
V. An N-bit ADC has $2^N - 1$ quantization levels.
Which of the above statements are INCORRECT?
(A) I, II and V
(B) II, III and IV
(C) III and V
(D) I, IV and V

2010

61. If an ADC has an offset error of +2 LSBs, the transfer function shifts:
(A) By an increasing amount as the input voltage rises
(B) Primarily at the full-scale value
(C) Creating a parabolic curve
(D) Left or right uniformly across all codes

2013

62. Which internal component in a Successive Approximation Register (SAR) ADC is compared against the input signal?
(A) An integrated ramp voltage
(B) A reference frequency
(C) The output of an internal DAC
(D) A delayed version of the input

2010

63. How many clock cycles does a basic N-bit SAR ADC require to complete one conversion?
(A) 1 cycle
(B) $\frac{N}{2}$ cycles
(C) N cycles
(D) 2^N cycles

Downloaded from www.pdf.tube

(D) Statistically independent and uncorrelated with respect to each other

2015

117. A common-mode rejection ratio (CMRR) of 100 dB implies that the common-mode gain is smaller than the differential gain by a factor of:
(A) 100
(B) 1,000
(C) 10,000
(D) 100,000

2022

118. Which input configuration is most susceptible to ground loop errors?
(A) Single-ended floating
(B) Differential floating
(C) Single-ended grounded
(D) Optically isolated

2014

119. A Programmable Gain Amplifier (PGA) in a DAS is typically placed:
(A) Directly following the digital-to-analog converter stage
(B) At the physical parallel digital output bus interface lines
(C) Inside the internal network of the R-2R ladder component
(D) Between the analog multiplexer and the input of the ADC

2025

120. If a DAS updates its analog output at a maximum rate of 100 kS/s, what is the minimum duration a specific voltage level is held?
(A) 1 µs
(B) 10 µs
(C) 100 µs
(D) 1 ms

2004

121. Hardware triggering utilizing a pre-trigger buffer allows a DAS to:
(A) Digitally increase the resolution of the ADC during post-event processing loops
(B) Capture and record data that occurred immediately prior to the trigger event
(C) Automatically switch off the power supply of the external sensors after recording
(D) Mathematically predict when the next external physical event will occur in time

2004

122. Virtual Instruments (VIs) in software like LabVIEW rely on:
(A) Specialized analog display tubes and physical control knobs mounted on rack enclosures
(B) Graphical block diagrams and software front panels interfacing with generic DAQ hardware
(C) Hard-coded ROM chips and firmware microcode driving dedicated microcontrollers exclusively
(D) Strictly parallel mechanical linkages and paper-based chart recorders without CPUs

2005

123. A standalone data logger in an environmental monitoring station is most likely to utilize which type of memory for reliability?
(A) Non-volatile solid-state Flash memory
(B) High-density volatile dynamic DRAM chip
(C) High-capacity magnetic analog storage tape
(D) Legacy physical punched paper ribbon tape

NODIA

2012

124. PCMCIA cards used for data storage in legacy loggers were standardized into Types I, II, and III. These types primarily differed in their:
(A) Operating voltage ranges
(B) Pin counts (68 vs 100 pins)
(C) Physical thickness
(D) Chemical composition

2023

125. In RS-232C, what is the standard function of the DCD (Data Carrier Detect) line?
(A) To transmit raw asynchronous serial data streams from the local terminal to remote sites
(B) To provide system clock synchronization and master-slave pulse distribution on the line
(C) To detect parity and framing errors within the internal hardware reception UART buffer
(D) To indicate to the DTE that a valid connection to the remote device has been established

2017

126. A standard RS-232C connection is generally limited to reliable communication distances of roughly:
(A) 5 centimeters
(B) 15 meters (50 feet)
(C) 1200 meters (4000 feet)
(D) 10 kilometers

2004

127. RS-485 achieves long transmission distances and high noise immunity by utilizing:

2014
191. A DSO with a sample rate of 1 GS/s and a memory depth of 1 Megapoint can capture a single-shot event for a maximum duration of:
(A) 1 microsecond
(B) 1 millisecond
(C) 10 milliseconds
(D) 1 second

2004
192. Equivalent-time sampling in a DSO builds a waveform by:
(A) Capturing a single continuous waveform in real-time mode
(B) Interpolating mathematical points from a slow sample rate
(C) Utilizing a much slower internal clock on standard ADC blocks
(D) Sampling across multiple repetitions of a periodic signal

2008
193. In a DSO, the "trigger holdoff" function is used to:
(A) Inhibit triggering on complex waves for a set time
(B) Freeze the waveforms on the display screen indefinitely
(C) Hold the input voltage steady during conversion cycles
(D) Artificially expand the input bandwidth of the front-end

2002
194. A spectrum analyzer displays signal information in which domain?
(A) Time domain
(B) Modulation domain
(C) Frequency domain
(D) Spatial domain

2025
195. Decreasing the Resolution Bandwidth (RBW) of a spectrum analyzer will:
(A) Lower the displayed noise floor and improve resolution, requiring a longer sweep time
(B) Elevate noise and reduce sweep time through wider filters
(C) Exert no observable effect on the measurement sweep time
(D) Broaden spectral peaks while reducing frequency detail

2010
196. The core mathematical algorithm used by digital spectrum analyzers to convert time-domain samples to frequency-domain data is the:
(A) Continuous Laplace Transform
(B) Discrete-time Z-Transform
(C) Taylor Series power expansion
(D) Fast Fourier Transform (FFT)

2011
197. A Logic Analyzer is fundamentally different from a DSO because it:
(A) Displays continuous analog voltage levels with high precision
(B) Monitors multi-channel digital states via logic thresholds
(C) Analyzes input signals exclusively within the frequency domain
(D) Measures static electrical resistance across passive devices

2007
198. In logic analyzer terminology, "state analysis" is best suited for:
(A) Quantifying setup and hold violations on digital signals
(B) Observing high-frequency analog ring artifacts on active lines
(C) Tracking microprocessor execution on active clock edges
(D) Measuring low-amplitude ripple voltages on power supply buses

2013
199. Network analyzers are categorized primarily into Scalar and Vector types. The defining capability of a Vector Network Analyzer is its ability to measure:
(A) Magnitude parameters only
(B) Active resistance ranges only
(C) Dynamic thermal variations
(D) Magnitude and phase angles

2009
200. S-parameters (Scattering parameters) measured by a VNA describe a network in terms of:
(A) Incident, reflected, and transmitted power waves
(B) Equivalent input and output network impedances
(C) AC voltages and currents under short-circuit tests
(D) Inductive and capacitive reactive properties only

Click Here to Buy book on Flipkart

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

2016
137. Which DSO triggering mode is best suited for capturing a brief, infrequent noise spike on a digital line?
(A) Standard edge triggering
(B) Glitch pulse triggering
(C) Analog video triggering
(D) AC power line triggering

2013
138. The dynamic range of a spectrum analyzer is typically defined as the ratio between:
(A) The highest frequency relative to the lowest measurable frequency
(B) The maximum input signal level before distortion to the displayed average noise floor (DANL)
(C) The fastest sweeping rate relative to the slowest sweep rate
(D) The physical screen width relative to the physical screen height

2011
139. In an FFT-based spectrum analyzer, windowing functions (like Hanning or Blackman) are applied to the time-domain data to reduce:
(A) Spectral leakage from finite sampling intervals
(B) Thermal noise floor within the measurement band
(C) High-frequency aliasing during digitization
(D) Power consumption of the DSP processing unit

2012
140. A timing logic analyzer is primarily characterized by its:
(A) Broad voltage measurement capability for precise analog waveforms
(B) Strict dependence on the target system clock for data transfer
(C) High asynchronous sample rate to capture timing and brief glitches
(D) Integrated capability to measure high-frequency wireless RF spectra

2019
141. S-parameters measured by a Vector Network Analyzer are used to characterize:
(A) Logic gate propagation delays and timing characteristics
(B) Static DC offset voltages and drift across temperature
(C) Mechanical vibration and resonance frequencies of sensors
(D) Linear electrical networks at high frequency ranges

2003
142. A traditional chart recorder is an example of what type of data acquisition?
(A) Strictly digital recording
(B) Hybrid analog-digital logs
(C) Continuous analog recording
(D) Serial digital bus logging

2002
143. Which of the following best describes signal conditioning for a thermocouple input?
(A) High-voltage attenuation combined with impedance matching
(B) Cold-junction compensation and low-level amplification
(C) High-frequency anti-aliasing filtering and attenuation
(D) Current-to-voltage conversion with galvanic isolation

2022
144. In a PC-based DAS using a multiplexer, if channels have significantly different source impedances, the primary risk is:
(A) Substantial increase in overall system dynamic range
(B) Large reduction in the total system power consumption
(C) Severe frequency aliasing of the digitized wave signal
(D) High inter-channel crosstalk and settling time errors

2008
145. What is the fundamental role of the break-before-make switching mechanism in an analog multiplexer?
(A) It prevents channel short-circuits during transitions
(B) It reduces overall power consumption in active systems
(C) It allows the switches to operate at higher speeds
(D) It minimizes the effects of high-frequency charge injection

2001
146. For a multiplexer settling time specification, typical error bands used for high-accuracy DAS are:
(A) 10.0% or 5.0% of the full-scale range
(B) 1.00 V or 2.00 V absolute voltage value
(C) 0.1% or 0.01% of the full-scale range
(D) 1.00 LSB value under typical conditions

Downloaded from www.pdf.tube

(A) Extremely high voltage level signals (typically up to ±50 V)
(B) Differential voltage transmission across a shielded twisted pair
(C) Fiber optic transmission lines with high attenuation
(D) Complex forward error correction codes implemented in terminal ICs

2014
128. What is the maximum recommended physical network length for an RS-485 bus operating at typical low baud rates?
(A) 15 meters
(B) 100 meters
(C) 1200 meters
(D) 5000 meters

2009
129. When an Ethernet-based DAS utilizes TCP/IP, what ensures that out-of-order packets are reassembled correctly at the destination?
(A) The Sequence Number field located within the TCP packet header structure
(B) The physical frame checks defined by the standard Ethernet MAC layer
(C) The source and destination route details stored in the IP address header
(D) The physical port mapping table maintained by the active hardware switch

2002
130. High-speed remote data loggers connected via Ethernet must handle "communication bottlenecks." This bottleneck is most commonly caused by:
(A) The maximum bandwidth limitations of the front-end analog-to-digital converter
(B) The maximum sampling clock frequency capability of the connected physical sensors
(C) Network traffic congestion and non-deterministic packet routing paths in switches
(D) High electromagnetic interference fields emitted by adjacent legacy RS-232 devices

2010
131. The IEEE 488 (GPIB) uses an 8-bit parallel data bus. How is data transfer synchronized between devices of different speeds?
(A) Through a 3-wire asynchronous hardware handshake
(B) By a rigid fixed clock frequency
(C) Using purely software-based timers
(D) By the master transmitting regardless of receiver status

2025
132. In an IEEE 488 bus, if three devices are listening to a Talker, when does the Talker consider a data byte successfully transferred?
(A) When the fastest Listener has accepted it
(B) When the controller tells it to stop
(C) After a predetermined time of 1 millisecond
(D) When the slowest Listener has accepted it

2007
133. The standard SCPI command `*RST` sent to an instrument performs which function?
(A) Reboots the internal processor and instrument's firmware
(B) Resets the entire instrument back to a known default state
(C) Reads and returns the contents of the main status register
(D) Requests execution of built-in self-test diagnostics runs

2016
134. Active Matrix LCDs achieve high refresh rates by using:
(A) A grid of intersecting passive electrode wires creating high parasitic capacitance
(B) A single global liquid crystal switching mechanism for the entire active screen
(C) Thin-Film Transistors (TFTs) integrated directly onto the glass for each pixel
(D) High phosphor persistence values designed to hold emission levels between frames

NODIA

2012
135. A major advantage of a Plasma display over an LCD panel in older instrumentation was:
(A) Lower overall electrical power consumption and dissipation
(B) Thinner physical profile and lightweight device packaging
(C) Complete structural immunity to permanent screen burn-in
(D) Better true black levels and wider viewing angles of pixels

2009
136. In a Digital Storage Oscilloscope (DSO), real-time sampling rate is strictly bounded by:
(A) The speed of the internal ADC
(B) The physical display resolution
(C) The memory depth
(D) The trigger holdoff setting

2023
158. In a Successive Approximation Register (SAR) ADC, the internal DAC must have a settling time that is:
(A) Long enough to match the entire conversion period
(B) Equal to precisely half of the system aperture time
(C) Faster than a single clock period of the algorithm
(D) Slower than the response time of the comparator

2011
159. A Dual-slope integrating ADC is characterized by two distinct integration phases. The duration of the first phase (signal integration) is:
(A) Proportional to the input voltage
(B) Fixed and constant
(C) Proportional to the reference voltage
(D) Controlled by the ambient temperature

2025
160. During the second phase of a Dual-slope ADC conversion, the integrator discharges at a rate proportional to:
(A) The peak input signal
(B) The clock frequency
(C) The ambient noise level
(D) A known reference voltage

2012
161. A first-order Sigma-Delta modulator consists of:
(A) An integrator, 1-bit ADC, and 1-bit DAC in feedback
(B) A long series consisting of 255 parallel comparators
(C) A standard SAR register connected to an R-2R ladder
(D) A programmable gain amplifier with a flash converter

2025
162. Noise shaping in a Sigma-Delta ADC is effective because it:
(A) Reduces the thermal noise floor across all frequencies
(B) Shapes the analog input signal into a steady square wave
(C) Pushes in-band quantization noise to higher frequencies
(D) Converts thermal noise into high common-mode signal noise

2001
163. Modern monolithic ADC/DAC packaging heavily utilizes CMOS technology primarily due to its:
(A) Low static power dissipation and high integration density
(B) Extremely high voltage and current handling capabilities
(C) Inherent structural immunity to magnetic interference
(D) Extremely high analog bandwidth compared to GaAs

2014
164. What is a significant thermal consideration when laying out a high-resolution monolithic ADC on a PCB?
(A) Maintaining a large thermal gradient across the active silicon
(B) Ensuring the silicon temperature remains consistently over 150°C
(C) Immersing the entire packaged device into specialized cooling fluid
(D) Isolating digital parts from the reference to limit thermal drift

2003
165. When calculating an error budget, which specification represents the systematic error that is independent of the input signal level?
(A) Gain error
(B) Offset error
(C) Non-linearity error
(D) Scale factor error

2016
166. A 10 V reference voltage in a DAS has a temperature coefficient of 5 ppm/°C. If the temperature changes by 20°C, what is the change in the reference voltage?
(A) 0.1 mV
(B) 1 mV
(C) 10 mV
(D) 100 mV

2005
167. Shielded twisted pair (STP) cabling in a DAS effectively minimizes:
(A) Electrostatic coupling fields only
(B) Electromagnetic coupling loops only
(C) Thermally generated internal sensor noise
(D) Both capacitive and inductive noise coupling

2014
168. To prevent a ground loop, the shield of a signal cable should typically be connected to ground at:

Click Here to Buy book on Amazon

2017

147. A Sample and Hold amplifier is placed in a DAS primarily to:
(A) Hold the fast-changing analog input during conversion
(B) Remove unwanted low-frequency thermal noise components
(C) Combine multiple analog signals into a single output
(D) Amplify the absolute amplitude of the input voltage

2007

148. Which component in a Sample and Hold circuit is most critical for minimizing the droop rate?
(A) A high-power buffer amplifier with high output current
(B) A high-speed mechanical switching relay mechanism
(C) A low-resistance discharging path connected to ground
(D) A low-leakage capacitor utilizing Teflon dielectric

2007

149. An ideal 16-bit DAC with a reference of 5 V has a resolution of:
(A) $\frac{5\,V}{65536}$
(B) $\frac{5\,V}{1000}$
(C) $\frac{5\,V}{256}$
(D) $\frac{5\,V}{16}$

2006

150. A major advantage of a multiplying DAC (MDAC) is its ability to:
(A) Process digital signals through high-order filters
(B) Generate stable negative output voltage references
(C) Scale a varying analog reference by digital input
(D) Function without an external analog reference voltage

2019

151. What limits the maximum full-scale output voltage of a standard non-multiplying DAC?
(A) The maximum clock switching frequency
(B) The resolution or total number of bits
(C) The error-checking parity bit standard
(D) The applied analog reference voltage

2010

152. In an N-bit parallel (weighted-resistor) DAC, the resistance of the MSB resistor is R. What is the resistance for the LSB?
(A) $\frac{R}{2^N}$
(B) $N \times R$
(C) $2^{N-1} \times R$
(D) $2^N \times R$

2014

153. A serial/indirect DAC architecture (such as a PWM-based DAC) typically requires which external component to produce a steady analog voltage?
(A) A high-pass filter
(B) A low-pass filter
(C) A fast comparator
(D) A multiplexer

NODIA

2009

154. According to the Nyquist theorem, a signal containing frequencies up to 20 kHz must be sampled at a minimum of:
(A) 10 kHz
(B) 20 kHz
(C) 40 kHz
(D) 80 kHz

2016

155. If a 1 kHz sine wave is sampled at 1.5 kHz, an alias frequency will appear at:
(A) 500 Hz
(B) 1.0 kHz
(C) 1.5 kHz
(D) 2.5 kHz

2024

156. An ADC with a non-monotonic transfer function is highly likely to exhibit:
(A) A differential non-linearity (DNL) of exactly zero
(B) Zero quantization error
(C) Missing codes
(D) High input leakage current

2015

157. For a standard, non-pipelined ADC, the maximum throughput rate is the inverse of the:
(A) acquisition time of the Sample and Hold circuit
(B) settling time of the internal reference voltage source
(C) master clock frequency of the processor
(D) total time required for acquisition and conversion

(D) Non-volatile magnetic core storage

2021

179. In an RS-232C link, the transmission speed is measured in Baud. For a standard binary serial link, 9600 Baud equals:
(A) 9600 bits per second
(B) 9600 bytes per second
(C) 9600 packets per second
(D) 9600 frames per second

2002

180. RS-232C pin configurations are defined for DTE (Data Terminal Equipment) and DCE (Data Circuit-terminating Equipment). A PC is typically configured as:
(A) DTE
(B) DCE
(C) A bridge device
(D) A repeater

2018

181. A null-modem cable is required when connecting:
(A) Two DTE devices directly together
(B) A DTE device to a DCE device
(C) A PC to a standard external modem
(D) Two DCE devices through an optical isolator

2022

182. RS-485 networks require termination resistors to match the characteristic impedance of the twisted pair. A common value for this resistor is:
(A) 50 ohms
(B) 120 ohms
(C) 1,000 ohms
(D) 10,000 ohms

2009

183. If termination resistors are omitted on a long, high-speed RS-485 line, what is the most likely consequence?
(A) The voltage levels will double, destroying the transceivers
(B) The baud rate will automatically increase
(C) The cable will overheat
(D) Signal reflections will occur, causing data corruption

2021

184. In Ethernet-based data acquisition, TCP (Transmission Control Protocol) is considered:
(A) Connection-oriented and reliable
(B) Connectionless and highly unreliable
(C) Strictly hardware-defined protocol
(D) Obsolete for any remote data logging

2022

185. A significant limitation of standard TCP/IP Ethernet for real-time control loops is:
(A) Unusually low maximum data throughput rate under typical loads
(B) Lack of determinism from variable routing and collision handling
(C) Inability to transport multi-bit digital sensor measurements
(D) Absolute restriction to only two nodes connected on a network

2021

186. The IEEE 488 (GPIB) standard is fundamentally a:
(A) Serial, point-to-point interface
(B) Parallel, multi-drop interface
(C) Wireless interface
(D) Current-loop interface

2014

187. In IEEE 488, the EOI (End or Identify) line is typically used to indicate:
(A) The final byte of a multi-byte message transfer
(B) The starting byte of an incoming command message
(C) A critical parity error detected in physical hardware
(D) A complete loss of power on the instrument chassis

2008

188. Which device role in an IEEE 488 setup dictates which instrument talks and which listens?
(A) Talker
(B) Listener
(C) Controller
(D) Peripheral

2023

189. A major component in an LCD panel that dictates viewing angle and contrast is the:
(A) Phosphor coating layer
(B) Deflecting electron gun
(C) Sealed glass vacuum tube
(D) Polarizing filter pair

2016

190. Projection systems used in modern control rooms frequently utilize DLP technology. DLP stands for:
(A) Digital Liquid Processing
(B) Direct Light Phosphor
(C) Digital Light Processing
(D) Dual Layer Plasma

Downloaded from www.pdf.tube

(A) A single point (typically at the DAS end)
(B) Both the sensor end and the DAS end
(C) Neither end (leaving the shield floating)
(D) Multiple points along the cable length

2018

169. Galvanic isolation techniques include optical, capacitive, and magnetic coupling. Which is best suited for transmitting a static DC signal continuously?
(A) Magnetic (transformer) isolation without modulation
(B) Optical isolation (Optocoupler)
(C) Capacitive isolation without modulation
(D) Piezoelectric isolation

2025

170. A Programmable Gain Amplifier (PGA) increases a 10 mV signal to 1 V for a 5 V ADC. What is the PGA gain setting?
(A) 10
(B) 50
(C) 100
(D) 500

2011

171. Bipolar input ranges in a DAS use a digital coding scheme where 0 V is often represented by half-scale code. This coding is known as:
(A) Offset Binary
(B) Straight Binary
(C) Binary Coded Decimal
(D) Gray Code

2025

172. The maximum update rate of a DAS output channel is fundamentally limited by:
(A) The resolution bandwidth of the anti-aliasing filter
(B) The thermal noise floor of the output power amplifier
(C) The DAC settling time and maximum digital interface data rate
(D) The type of power supply regulation used in the chassis

2007

173. Digital I/O lines on a DAQ card are often characterized as "TTL compatible". This implies a guaranteed minimum high-level output voltage of approximately:
(A) 1.5 V
(B) 2.4 V
(C) 3.3 V
(D) 5.0 V

2008

174. In hardware triggering, a "post-trigger" acquisition mode implies:
(A) Data is collected before the trigger event occurs
(B) Data is collected at random intervals
(C) Data is collected after the trigger event occurs
(D) The trigger signal is ignored during data acquisition

2017

175. A counter/timer chip can measure the frequency of a signal by counting the number of signal pulses that occur within a window generated by a:
(A) Voltage-controlled oscillator driven by thermal noise
(B) Precision internal reference clock timebase
(C) Monostable multivibrator triggered by power line noise
(D) Low-pass filtered digital-to-analog converter output

2023

176. Data Acquisition Virtual Instruments (VIs) allow rapid reconfiguration of a measurement system primarily because:
(A) They physically re-route analog wiring on the interface board
(B) They use programmable analog arrays that require no calibration
(C) They rely on virtual memory to bypass physical hardware limitations
(D) The user interface and signal processing are defined in software

2017

177. A distributed data logger system is highly beneficial when:
(A) Sensors are geographically dispersed, reducing analog run lengths
(B) Sensors are positioned extremely close, under one meter from the PC
(C) Systems demand absolute zero-latency hardware trigger interactions
(D) Simple single-channel measurement setups are exclusively utilized

NODIA

2001

178. PCMCIA memory cards used in older data loggers stored data in non-volatile solid-state memory, often referred to as:
(A) Volatile high-speed static RAM
(B) Dedicated serial EEPROM chips
(C) Solid-state ATA or Linear Flash

2017

201. Which chart recorder type uses a mechanical pen linked to a galvanometer to draw continuously on moving paper?
(A) Electronic multipoint logging recorder
(B) Direct-writing oscillographic recorder
(C) Microcontroller-based digital data logger
(D) Multi-channel thermal array print recorder

2018

202. The fundamental limitation of a mechanical chart recorder for capturing high-frequency signals is:
(A) The electrical resistance of the paper medium
(B) Mechanical inertia and friction of pen parts
(C) The chemical formulation and color of the ink
(D) Physical velocity limitations of speed of light

2016

203. Which signal is considered a discrete-time, continuous-amplitude signal?
(A) Sample and Hold output voltage before the ADC converter
(B) Unconditioned analog sensor signals before multiplexing
(C) Fully quantized binary stream at the output of the ADC
(D) Transmitted byte frames across standard RS-232 serial

2006

204. In basic signal conditioning, what does a low-pass filter specifically remove from an analog sensor signal?
(A) Constant static DC offsets and low drift levels
(B) Low-frequency $\frac{1}{f}$ flicker noise fluctuations
(C) High-frequency noise and out-of-band interference
(D) Fundamental frequency components of interest

2012

205. The configuration of a hybrid DAS differs from a PC-based DAS by:
(A) Relying entirely on plug-in internal PCIe expansion cards
(B) Utilizing strictly continuous analog recording instruments
(C) Eliminating the requirement for active electronic memories
(D) Using external acquisition chassis with a central host PC

2014

206. Multiplexer switching mechanisms often utilize solid-state switches instead of electromechanical relays primarily to achieve:
(A) Greatly elevated levels of contact resistance
(B) Perfect continuous electrical galvanic isolation
(C) Faster switching speeds and longer device lifespan
(D) Complete elimination of capacitive charge injection

2023

207. A multiplexer channel configuration described as "differential" requires how many physical switches per channel?
(A) 1
(B) 2
(C) 4
(D) 8

2015

208. The term "acquisition time" in a Sample and Hold circuit specifically includes:
(A) Propagation delays through digital triggering logic paths
(B) Processing time of the ADC to calculate binary codes
(C) Complete discharge time of integrated backup batteries
(D) Capacitor charging and input amplifier settling time

2015

209. To minimize droop rate in a Sample and Hold circuit, the output buffer amplifier must have:
(A) Extremely low input bias current from FET inputs
(B) Significantly reduced levels of input impedance
(C) Unusually high levels of amplifier bias current
(D) Low output impedance characteristics exclusively

2002

210. A 16-bit DAC offers how many discrete analog output levels?
(A) 16
(B) 256
(C) 16,384
(D) 65,536

2023

211. The specification of a DAC known as "monotonicity" means that:

Click Here to Buy book on Flipkart

(A) The analog output consistently increases or remains constant as the digital input code increases
(B) The analog output alternates between positive and negative
(C) The DAC system generates a continuous, single-tone output
(D) The internal analog settling time remains fully constant

2013
212. In a weighted-resistor DAC, if the MSB resistor is 10 kΩ, what is the required resistance for the LSB in a 4-bit DAC?
(A) 10 kΩ
(B) 20 kΩ
(C) 40 kΩ
(D) 80 kΩ

2001
213. Which topology is most practical for a high-resolution (e.g., 16-bit) monolithic DAC?
(A) Weighted-resistor network
(B) R-2R ladder network
(C) Flash architecture
(D) Purely mechanical relays

2007
214. If a signal is sampled at exactly the Nyquist rate, recovery of the original signal can be problematic due to:
(A) Generation of unwanted high-order harmonic distortion
(B) Aliasing effects originating from severe subsampling
(C) Infinite bandwidth demands on reconstruction filters
(D) Total disappearance of internal ADC quantization noise

2012
215. The Signal-to-Quantization-Noise Ratio (SQNR) of an ideal N-bit ADC is approximately given by the formula:
(A) $3.01N$ dB
(B) $10\log(N)$ dB
(C) $20\log(N)$ dB
(D) $6.02N + 1.76$ dB

2025
216. An ADC with a missing code indicates that its Differential Non-Linearity (DNL) at that point is:
(A) less than -1 LSB
(B) exactly 0 LSB
(C) exactly +0.5 LSB
(D) equal to the Integral Non-Linearity (INL)

2001
217. In a SAR ADC, what is the function of the Successive Approximation Register?
(A) It generates a linear analog voltage ramp to drive comparison
(B) It tracks the digital guess, updating it via comparator feedback
(C) It filters high-frequency noise from the incoming analog wave
(D) It provides continuous electrical isolation for signal safety

2019
218. The primary advantage of a Dual-slope ADC over a SAR ADC is:
(A) Substantially faster conversion rates and sampling speeds
(B) Inherent noise integration to reject line frequencies
(C) Lower overall bit resolution and lower circuit cost
(D) Immediate conversion triggered on a single clock edge

2019
219. Sigma-Delta ADCs are predominantly used for:
(A) Precision, low-bandwidth instrumentation and audio applications
(B) Ultra-fast digitization blocks inside digital storage oscilloscopes
(C) Direct digitization and capture of microwave frequency signals
(D) High-speed processing pipelines designed for analog video feeds

2002
220. The decimation filter in a Sigma-Delta ADC is a type of:
(A) Analog low-pass filter
(B) Analog high-pass filter
(C) Digital low-pass filter
(D) Digital high-pass filter

NODIA

2002
221. Which aspect of a monolithic ADC package poses the greatest challenge compared to a hybrid package?
(A) Connecting multiple high-current power supply input pins externally
(B) Shrinking the physical footprint to meet small modern package specs
(C) Achieving high-speed digital logic state transitions on chip lines
(D) Integrating trimmed passives and isolated

domains on a single die

2003

222. An error budget analysis for a DAS must consider thermal drift. If an ADC has a gain drift of 10 ppm/°C, a 50°C temperature change will cause a gain error of:
(A) 0.005% (50 ppm)
(B) 0.05% (500 ppm)
(C) 0.5% (5,000 ppm)
(D) 5.0% (50,000 ppm)

2015

223. What is a primary cause of offset error in an analog signal conditioning circuit?
(A) Finite resolution limits from signal quantization
(B) Input bias currents and voltage mismatches in op-amps
(C) Exceptionally high sampling frequencies in the system
(D) Jitter fluctuations present on digital clock signals

2002

224. To effectively eliminate a ground loop, an instrumentation engineer should:
(A) Establish multiple ground points with different electrical potentials
(B) Sever ground lines entirely, allowing systems to float dangerously
(C) Install significantly thicker wiring for common ground connections
(D) Use isolation components to break electrical conduction paths

2017

225. A Programmable Gain Amplifier (PGA) enhances the DAS resolution for low-level signals by:
(A) Boosting weak signals so they utilize more ADC codes
(B) Lowering reference voltages of conversion chips on the fly
(C) Increasing sampling rates to gather more data points quickly
(D) Filtering out all high-frequency noise prior to digitizing

2003

226. If a DAS has a bipolar input range of ± 10 V and an ADC resolution of 16 bits, the LSB size is approximately:
(A) 152 µV
(B) 305 µV
(C) 1.2 mV
(D) 30.5 mV

2010

227. Software triggering in a DAQ Virtual Instrument (VI) is limited by:
(A) The latency and non-determinism of the computer's operating system
(B) Physical threshold switching speeds of internal analog comparators
(C) Absolute physical length limitations of standard RS-232 cables
(D) Available capacity and write speeds of standard storage systems

2018

228. A counter/timer configured for "pulse width measurement" uses an internal high-frequency clock to measure:
(A) The physical time span between identical edges of a period
(B) The peak continuous analog voltage amplitude of active pulses
(C) The accumulated total count of digital pulses in one second
(D) The duration a signal remains in a high or low logic state

2008

229. Data loggers designed for remote, long-term deployment prioritize which specification?
(A) Extremely high continuous sampling rates
(B) Low power consumption and robust storage
(C) Large, ultra-high-resolution displays
(D) Real-time 3D mathematical graphing power

2002

230. The RS-232C standard specifies asynchronous communication. "Asynchronous" means:
(A) Sender and receiver units share a synchronized physical clock line
(B) Transmission runs continuously without ever using framing stop bits
(C) Timing is derived from start/stop bits without a clock line
(D) Transmission is unidirectional and can only flow in one direction

NODIA

2009

231. The voltage levels of RS-232C are considered "inverted" logic because:
(A) Both communication signal levels are strictly positive
(B) Positive voltage is logic 1, negative is logic 0
(C) Signals are sent differentially over dual-wire pairs
(D) Negative voltage is logic 1, positive is logic 0

rates far higher than the Nyquist frequency, which distributes quantization noise over a much wider spectrum. Additionally, noise shaping feedback loops mathematically shift the bulk of this quantization noise into higher frequencies, where it is subsequently removed by a digital low-pass filter.

20. (B) I, II and IV
Sigma-delta converters utilize oversampling ratios much greater than unity to distribute quantization noise across a wider band. Modulators use feedback loops to perform noise shaping, pushing this noise into high-frequency regions. Decimation filters then process the high-rate digital stream, removing high-frequency noise and lowering the sampling rate to standard levels for processing.

21. (B) Are fabricated on a single silicon chip
Monolithic converters are integrated circuits fabricated entirely on a single silicon substrate, offering compact size, lower production cost, and high reliability. This differs from hybrid designs, which combine separate semiconductor dies, substrates, and passive components in a single package. Monolithic construction reduces parasitic parameters and eliminates the interconnections associated with hybrid designs.

22. (C) Thermal gradients causing thermoelectric voltages and drift between internal components
Hybrid devices contain multiple distinct chips and components mounted within a single package, creating localized temperature differences during operation. These thermal gradients generate unwanted thermoelectric voltages at junctions of dissimilar metals, leading to drift and calibration errors. Monolithic devices are less prone to this issue because their components share a single, uniform silicon die.

23. (D) Offset error
Static errors remain constant over time and are independent of signal dynamics or sampling rates. Offset error represents a constant DC shift in the transfer function, where the output deviates from zero even with zero input. This differs from dynamic errors like aperture jitter, settling time, or crosstalk, which depend on frequency and timing.

24. (A) Square root of the sum of the squares of individual errors
When combining multiple independent and uncorrelated error sources in a system, a simple algebraic addition overestimates the total uncertainty. The root sum square method provides a statistically realistic estimate by squaring each individual error value, summing those squared values, and then calculating the square root of that sum, representing the standard deviation of total error.

25. (B) II and IV
Ground loops are formed when multiple grounding points create conductive loops, so connecting grounds at multiple points worsens rather than eliminates the problem. Galvanic isolation prevents direct DC current flow while permitting signal transmission, making statements to the contrary incorrect. Effective noise reduction instead relies on single-point grounds and proper electrical isolation barriers.

26. (B) Break ground loops and protect equipment from high common-mode voltages
Galvanic isolation physically separates the input and output signal paths of a measurement system to prevent direct current flow. This separation breaks ground loops that introduce noise and errors into analog measurements. Additionally, it protects sensitive downstream digital electronics from potentially damaging high-voltage transients and large common-mode signals present on input lines.

27. (A) To optimize the input signal amplitude to match the ADC full-scale range
A programmable gain amplifier adjusts its amplification factor under software control to scale incoming analog signals of varying levels. This dynamic adjustment ensures that the signal amplitude matches the full-scale input span of the digitizer, maximizing the effective resolution and signal-to-noise ratio of the system while preventing signal clipping.

28. (C) 0x800
A twelve-bit analog-to-digital converter divides its full-scale range into four thousand ninety-six discrete levels, spanning hexadecimal codes from zero to FFF. An input of five volts represents exactly half of the ten-volt unipolar range. Consequently, the ideal digital output code is half of the maximum scale, which corresponds to

Downloaded from www.pdf.tube

(A) Heating a microscopic linear array on thermal paper
(B) Dragging a heated pen element across standard paper
(C) Deploying a high-precision digital inkjet nozzle
(D) Deflecting laser beams directly onto film mediums

2023
244. When selecting an ADC for a Data Acquisition System, increasing the resolution (number of bits) directly improves the system's:
(A) Maximum achievable sampling rate of the ADC
(B) Complete electrical immunity to ground loops
(C) Overall operating power consumption levels
(D) Dynamic range and minimum detectable signals

2016
245. Which of the following best characterizes a Sigma-Delta DAC?
(A) It demands extremely precise laser-trimmed R-2R resistors
(B) It uses oversampling, noise shaping, and low-pass filtering
(C) It utilizes a vast array of high-speed parallel comparators
(D) It functions using an integrating capacitor with a counter

2001
246. In DAS architectures, DMA (Direct Memory Access) is heavily utilized to:
(A) Compress the incoming raw digital signal stream efficiently
(B) Provide continuous galvanic isolation between circuit domains
(C) Transfer data to PC memory without heavily loading the CPU
(D) Boost the absolute voltage amplitude of weak input signals

2019
247. The "settling time" of an operational amplifier in a signal conditioning circuit is the time required for the output to:
(A) Transition to and reach 50% of its target final voltage
(B) Return completely back to a zero-volt baseline status
(C) Begin changing states immediately after an input step
(D) Enter and remain within a defined error band after a step

2021
248. Multiplexer crosstalk becomes significantly worse at:
(A) Higher frequencies due to parasitic capacitive coupling
(B) Lower frequencies where inductive coupling is diminished
(C) Zero Hz (DC) where static voltage levels are constant
(D) Standard room temperatures under standard test conditions

2004
249. A key advantage of using a charge-redistribution SAR ADC (using capacitors) over a resistor-based SAR ADC is:
(A) Ability to measure exceptionally large high-voltage levels
(B) Lower power consumption and better matching in CMOS designs
(C) Complete structural elimination of internal analog comparators
(D) Requirement of significantly fewer clock cycles per conversion

2021
250. The "aliasing" phenomenon in digital signal processing causes high-frequency signals to appear as:
(A) Significant increases in static DC offset levels
(B) Lower frequency artifacts in the digitized data
(C) Missing binary codes at the physical ADC outputs
(D) Greatly increased amplitude of the signal waves

2004
251. A 12-bit ADC has a full-scale range of 10 V. If the INL is specified as ± 1 LSB, what is the maximum voltage error introduced strictly by non-linearity?
(A) ≈ 1.22 mV
(B) ≈ 2.44 mV
(C) ≈ 4.88 mV
(D) ≈ 10.00 mV

2015
252. The fundamental operational difference between a Flash ADC and a Pipeline ADC is that a Pipeline ADC:
(A) Utilizes only a single analog comparator block for determinations

NODIA

(B) Relies on purely mechanical or electromechanical switching relays
(C) Trades conversion latency for high throughput at high resolution
(D) Employs a continuous dual-slope integration and discharge cycle

2014
253. Which noise source is fundamentally unavoidable in any resistive signal conditioning circuit?
(A) Induced ground loop currents
(B) 50/60 Hz mains interference
(C) Inter-channel signal crosstalk
(D) Johnson-Nyquist thermal noise

2011
254. When designing a low-noise DAS, why are differential inputs strictly preferred over single-ended inputs for sensors placed far from the ADC?
(A) They require half the physical number of signal wires
(B) They double the maximum achievable ADC sampling rates
(C) They cancel common-mode noise picked up along the lines
(D) They eliminate the need for anti-aliasing input filters

2017
255. A VI (Virtual Instrument) in a software-based DAS typically features a "Front Panel" and a:
(A) Back panel
(B) Block Diagram
(C) Circuit board
(D) Power supply

2021
256. Which communication protocol uses a 9-pin D-subminiature connector as its most common physical interface on older PCs?
(A) IEEE 488
(B) Ethernet
(C) RS-485
(D) RS-232C

2011
257. An RS-485 network is typically wired in a:
(A) Daisy-chain (bus) topology
(B) Point-to-point star topology
(C) Closed active ring topology
(D) Interconnected mesh topology

2006
258. IEEE 488.2 improved upon IEEE 488.1 primarily by defining:
(A) Standard physical connector sizes and mechanical pin dimensions
(B) Transceiver electrical voltage levels and signal noise limits
(C) Standard data formats, status reporting, and common commands
(D) High-speed fiber optic physical transmission line alternatives

2009
259. LCD displays rely on the polarization of light. Which component electrically controls the rotation of light polarization?
(A) The active liquid crystal layer
(B) The LED or CCFL backlight unit
(C) The integrated RGB color filters
(D) The protective glass substrate

2002
260. Which parameter of a DSO defines its vertical amplitude resolution?
(A) The physical memory depth of the capture channel
(B) The maximum real-time sampling rate of the system
(C) The bandwidth of the analog input amplifier block
(D) The bit resolution of its internal ADC converter

2001
261. In a Spectrum Analyzer, if a signal is larger than the dynamic range of the instrument, it will likely cause:
(A) The electronic display system to shut down completely
(B) The mixer to generate spurious intermodulation distortion
(C) The resolution bandwidth (RBW) filter to narrow automatically
(D) The frequency sweep action to stop running immediately

2014
262. Which instrument is essential for verifying the proper operation of a complex, parallel digital data bus?
(A) Scalar Network Analyzer
(B) Digital Storage Oscilloscope (single channel)
(C) Logic Analyzer
(D) Spectrum Analyzer

2022
263. When using an equivalent-time sampling DSO, the target signal must be:
(A) A single, non-repeating transient

Click Here to Buy book on Amazon

(B) Strictly a DC voltage
(C) Below the Nyquist frequency of the real-time clock
(D) Periodic and highly repetitive

2018
264. To analyze the reflection characteristics (Return Loss or VSWR) of an RF antenna, which instrument is used?
(A) Vector Network Analyzer
(B) Multi-channel Logic Analyzer
(C) Galvanometer Chart Recorder
(D) Analog Signal Multiplexer

2002
265. What is the fundamental mathematical operation a Digital Storage Oscilloscope uses to provide an FFT display?
(A) Converting frequency domain samples into a time domain display
(B) Converting time domain samples into a frequency spectrum
(C) Multiplying input signals directly by local oscillators
(D) Integrating the incoming analog signal continuously over time

2001
266. Which physical phenomenon dictates the minimum achievable droop rate in a perfect S/H circuit?
(A) Absolute physical propagation speed limits of light waves
(B) Capacitor leakage currents and buffer input bias currents
(C) Maximum analog bandwidth limits of incoming sensor signals
(D) Total quantizing resolution of the down-stage ADC block

2017
267. "Throughput rate" of a multiplexed DAS is generally lower than the raw conversion rate of the ADC because of:
(A) The required multiplexer settling and Sample and Hold acquisition times
(B) Refresh rates and processing speeds of computer monitors
(C) Interface formats and solid-state memory card standards
(D) Physical length and capacitive loading of RS-232 cables

2011
268. Why is a simple R-2R ladder preferred over a weighted-resistor network for a 12-bit DAC?
(A) It requires exactly twelve distinct, highly precise resistor values
(B) It operates completely without the need of external reference voltages
(C) It needs only two resistor values (R and $2R$), easing fabrication
(D) It inherently provides near-infinite resolution on standard designs

2012
269. The quantization error of an ADC behaves mathematically like:
(A) A high-frequency continuous sinusoidal wave signal
(B) A constant, static DC voltage offset error value
(C) A passive, single-pole low-pass filtering effect
(D) An additive, uniformly distributed white noise source

2017
270. In modern remote data acquisition, SCPI commands over TCP/IP (LXI standard) have largely replaced which older bus standard for rack-mount instrumentation?
(A) Standard Universal Serial Bus (USB)
(B) Inter-Integrated Circuit (I2C)
(C) IEEE 488 (GPIB) interface bus
(D) Serial Peripheral Interface (SPI)

****

NODIA

2012
232. An RS-485 transceiver operates using differential signaling, meaning the logic state is determined by:
(A) The voltage difference between the A and B lines
(B) The absolute voltage of the A line relative to ground
(C) The absolute voltage of the B line relative to ground
(D) The current flowing in the ground wire

2023
233. In an RS-485 network, what is the function of fail-safe biasing resistors?
(A) To distribute auxiliary DC power to remote measurement nodes
(B) To hold the bus in a known state when transmitters are idle
(C) To function continuously as a secondary redundant datapath
(D) To increase the maximum achievable transmission baud rates

2002
234. In TCP/IP communication for remote DAS, the "IP" portion of the protocol is responsible for:
(A) Verifying and ensuring that transmitted data is not corrupted
(B) Routing the packets to the correct destination IP address
(C) Converting incoming raw analog signals into digital values
(D) Displaying the processed network data on graphical screens

2014
235. The 3-wire handshake in IEEE 488 (GPIB) allows devices of varying speeds to communicate reliably. Which line indicates that a listener is ready to accept data?
(A) NRFD (Not Ready For Data)
(B) DAV (Data Valid signal)
(C) NDAC (Not Data Accepted)
(D) ATN (Attention status)

2018
236. What is the fundamental structure of a SCPI command string sent to an instrument?
(A) A raw sequence of binary hexadecimal bytes
(B) An XML document containing device properties
(C) A colon-separated hierarchical text string
(D) A continuous pulse-width modulated signal

2001
237. Liquid Crystal Displays (LCDs) do NOT emit light themselves; they require:
(A) An external, strong static magnetic field
(B) High-voltage gas-plasma discharge currents
(C) A rapidly sweeping internal electron beam
(D) An active backlight unit to illuminate pixels

2023
238. In a Digital Storage Oscilloscope, the bandwidth of the analog front-end should typically be:
(A) Precisely equal to the maximum design sampling rate
(B) Strictly less than half of the Nyquist limit value
(C) At least 3 to 5 times the frequency of interest
(D) Exactly 1 kHz regardless of input signal features

2022
239. Spectrum Analyzers utilizing sweeping local oscillators must sweep slowly enough to allow which component to fully respond?
(A) The input RF attenuation network
(B) The resolution bandwidth (RBW) filter
(C) The digital screen display processor
(D) The main instrument power supply unit

2013
240. The displayed average noise level (DANL) of a spectrum analyzer dictates its:
(A) Maximum input power handling capacities
(B) Absolute fastest measurement sweep times
(C) Physical package size and overall weight
(D) Ultimate sensitivity to detect small signals

2005
241. Logic Analyzers capture data synchronously or asynchronously. Synchronous capture is also known as:
(A) State analysis
(B) Timing analysis
(C) Spectral analysis
(D) Network analysis

2007
242. S-parameters $S_{\{11\}}$ and $S_{\{21\}}$ refer respectively to:
(A) Output reflection coefficient and reverse transmission coefficient
(B) Voltage gain and current gain
(C) Input reflection coefficient and forward transmission coefficient
(D) Inductance and capacitance

2011
243. A thermal array chart recorder prints waveforms by:

Downloaded from www.pdf.tube

fifty-six. Dividing the five-volt full-scale range by this value yields approximately nineteen point five three millivolts.

10. (A) P-4, Q-1, R-3, S-2
Digital-to-analog converter specifications define critical performance aspects of signal reconstruction. Resolution corresponds to the number of distinct levels produced, while full-scale voltage indicates the maximum possible output. Settling time denotes the interval required to reach the final value within a specific band, and accuracy measures how close the actual output is to its theoretical target.

11. (A) Requires a wide range of precision resistor values for high-resolution configurations
Weighted-resistor converters face major manufacturing hurdles because they require a highly diverse span of component values that double with each successive bit. For high-resolution systems, achieving precise matching across this vast range becomes extremely difficult, leading to manufacturing defects, severe temperature drift, and non-linearities in the reconstructed analog output waveform.

12. (B) Two
The R-two-R ladder network simplifies the fabrication of digital-to-analog converters by utilizing only two distinct resistor values, where one is exactly double the resistance of the other. This configuration overcomes the limitations of weighted systems, as matching two values with high precision is significantly easier than matching a wide range of values.

13. (D) Greater than twice the highest frequency component present in the input signal
To guarantee complete reconstruction of a continuous-time signal without distortion, the sampling process must respect the Nyquist theorem. This fundamental rule states that the sampling rate must exceed twice the highest frequency component contained in the input signal. Insufficient sampling rates lead to spectral overlap, causing irreversible aliasing errors in the digital representation.

14. (C) The mapping of a continuous range of analog values to discrete digital codes
Quantization error is an inherent limitation of the digitization process, caused by converting an infinitely variable analog signal into a finite set of digital codes. Because the digital representation is step-like, there is a small difference between the actual analog input and the nearest digital step, producing a permanent noise component in the signal.

15. (A) I and II
Conversion time dictates the maximum speed at which an analog-to-digital converter can process inputs, directly limiting system throughput. Missing codes represent a severe form of non-linearity where specific digital output states can never be reached. Differential non-linearity measures step-to-step variations, whereas overall deviation from a straight line is defined as integral non-linearity.

NODIA

16. (D) Missing codes in the digital output
Severe differential non-linearity indicates that the actual step sizes of an analog-to-digital converter deviate significantly from the ideal one-LSB width. If this deviation is large enough, certain transition steps can vanish entirely, meaning the device cannot output those specific digital codes. This results in missing codes and localized distortion in the digital data.

17. (A) Flash (parallel)
Flash converters provide the highest speed among digitizing architectures because they execute the conversion in a single step using a large parallel array of comparators. This direct approach eliminates the need for sequential clock cycles or ramp integrations, allowing instantaneous output generation, which is ideal for high-bandwidth applications like digital oscilloscopes and radar systems.

18. (C) High resolution and excellent rejection of power-line electromagnetic noise
Dual-slope integrating converters are highly valued for low-frequency precision measurements because their integration period can be synchronized with power-line cycles. This mathematical integration inherently averages out periodic AC noise, providing superb common-mode rejection. Consequently, they are widely chosen for digital voltmeters and industrial weighing systems where high resolution outweighs fast speed.

19. (A) Oversampling and noise shaping
Sigma-delta converters achieve high-resolution performance by sampling the input signal at

ANSWERS

1. (A) A signal having a continuous range of values at every instant of time
Analog signals in continuous time represent physical phenomena by maintaining unbroken trajectories across both the temporal and amplitude domains. This means that the signal is defined at every infinitely small increment of time, and its value can vary continuously over a specified range, distinguishing it from discrete or quantized digital signals used in computing.

2. (C) Low-pass filter
An anti-aliasing filter must restrict the bandwidth of the incoming analog signal before it reaches the digital converter. By utilizing a low-pass response, the filter attenuates all high-frequency noise and signal components situated above the Nyquist frequency. This prevention of spectral folding ensures that high-frequency components do not overlap and corrupt lower-frequency measurements.

3. (A) To match source impedance and scale sensor signals for the analog-to-digital converter
Signal conditioning amplifiers perform crucial analog processing by scaling weak transducer outputs to utilize the full dynamic range of digital converters. They also provide high input impedance to prevent loading effects on sensitive sensors, while maintaining low output impedance for optimal signal transfer. This ensures accurate and noise-free voltage translation before digitization occurs within the data system.

4. (D) The slowest conversion element, typically the ADC or the multiplexer settling time
The maximum throughput rate in a hybrid architecture is fundamentally restricted by the slowest process in the analog signal path. This delay typically stems from the analog-to-digital converter conversion period or the time required for the multiplexer output to settle after switching channels. Consequently, these hardware elements establish the upper boundary for data acquisition speeds.

5. (A) Both A and R are true and R is the correct explanation of A.
Capacitive coupling between adjacent channels in a multiplexed data acquisition system introduces unwanted signal leakage, which directly degrades measurement accuracy. This phenomenon is defined as crosstalk, where electric fields allow energy from an active channel to transfer to an inactive neighbor. Because this coupling directly explains the resulting measurement errors, both statements are correct and logically related.

6. (C) Reach and remain within a specified error band of its final value after a channel change
The settling time of an analog multiplexer defines the duration needed for the output signal to stabilize after switching to a new input channel. Transient voltage fluctuations occur during transitions, meaning the system must wait until the signal enters and stays within a predetermined tolerance band around its final value before accurate digitization can begin.

7. (D) Acquisition time
Acquisition time is the vital interval required by a sample and hold circuit to track the input signal within a designated error margin. During this phase, the internal switch closes, allowing the input source to charge the hold capacitor to the new signal level. This duration dictates the maximum sampling rate of the front-end system.

8. (A) High leakage current of the hold capacitor or output buffer amplifier
A high droop rate represents an undesirable decay of the stored voltage while the circuit is in its hold state. This voltage loss occurs because current slowly escapes from the hold capacitor through its own leakage resistance, the open sampling switch, or the input paths of the buffer amplifier. Minimizing these leakage paths preserves signal integrity.

9. (C) 19.53 mV
The size of the least significant bit represents the smallest analog voltage increment that a converter can resolve. For an eight-bit converter, the total number of discrete intervals equals two raised to the power of eight, which is two hundred

Click Here to Buy book on Flipkart

decimal two thousand forty-eight or hexadecimal eight hundred.

29. (D) Precise timing and synchronization with an external event are strictly required
Hardware triggering uses a dedicated electrical signal to initiate data acquisition instantly, bypassing the software layers of the operating system. This method eliminates the unpredictable latencies and timing jitter associated with CPU execution loops, making it essential when precise, real-time synchronization with external physical events is mandatory for accurate measurements.

30. (C) Channel Selection → Amplification → Sample/Hold → A/D Conversion
In a standard multi-channel system, the analog multiplexer first selects the desired input channel. Next, a programmable amplifier scales the chosen signal to optimize its amplitude. The sample and hold circuit then captures this stable voltage level, holding it constant while the analog-to-digital converter performs the final conversion to digital code.

31. (B) Generating precise sampling rates and measuring external signal pulse widths
Counter and timer modules in data systems serve as highly precise temporal references. They utilize stable internal oscillators to generate exact clock rates for triggering analog conversions at uniform intervals. Additionally, they can measure external digital signals by counting clock pulses between transitions, allowing accurate determination of frequencies, periods, and pulse widths.

32. (D) Traditional hardware front-panels and dedicated data processing modules
Virtual instruments leverage software to emulate the functionality of physical laboratory equipment on a standard computer. By replacing expensive hardware front panels, physical knobs, and dedicated display units with interactive graphical user interfaces, virtual instruments allow users to configure measurements, visualize real-time waveforms, and perform advanced data analysis digitally on a single screen.

33. (A) Internal memory, independent power, and autonomous operation capabilities
Standalone data loggers are self-contained instruments designed to collect data independently of a host computer. They contain internal non-volatile memory for local storage, built-in battery or solar power supplies, and onboard microcontrollers for autonomous control. This allows them to operate reliably in remote, harsh environments where continuous PC connections are impractical.

34. (C) Expanding non-volatile memory storage
PCMCIA cards served as a standard expansion interface for legacy portable data systems, primarily providing removable non-volatile storage. Since early loggers lacked large built-in solid-state memories, these rugged cards allowed users to store vast quantities of logged field data and easily transfer the physical media to a computer for analysis.

35. (A) I, II, III, IV
During a standard RS-two-thirty-two hardware handshake, the terminal first asserts Data Terminal Ready to signal its presence. To initiate transmission, the sending device activates Request to Send. The receiving system responds with Clear to Send once its buffers are clear, after which data transmission begins over the transmit data line in a coordinated sequence.

36. (A) -3 V to -15 V
The RS-two-thirty-two standard employs negative logic levels to ensure high noise immunity over serial connections. A logic high state, also known as a mark, is defined by a negative voltage ranging from minus three to minus fifteen volts. Conversely, a logic low or space state is represented by a positive voltage within the same range.

37. (B) RS-485 supports multi-drop network topologies
Unlike RS-two-thirty-two, which is limited to point-to-point connections, the RS-four-eight-five standard supports multi-drop configurations. This allows multiple transmitters and receivers to share a single differential bus. Its high-impedance receiver inputs enable up to thirty-two standard unit loads to communicate on the same network, simplifying wiring in distributed industrial environments.

38. (C) At the two physical ends of the differential transmission line
To prevent signal reflections that cause data corruption in RS-four-eight-five networks, termination resistors must match the characteristic impedance of the transmission

Downloaded from www.pdf.tube

cable. These resistors are placed only at the two extreme physical ends of the differential bus, ensuring that high-frequency signal energy is absorbed instead of bouncing back along the communication line.

39. (D) Protocol overhead and network latency affecting strict real-time determinism
Integrating Ethernet into data systems provides high bandwidth but introduces non-deterministic behavior. This bottleneck is caused by the overhead of wrapping data in TCP/IP packets and the variable delays associated with network routing and packet collisions. These factors create timing jitter, making standard Ethernet systems less suitable for strict real-time applications.

40. (A) Both A and R are true and R is the correct explanation of A.
Standard TCP/IP networks are not inherently deterministic because they prioritize reliable delivery over precise timing. The protocol manages transmission issues through packet acknowledgment and variable routing delays, which introduces unpredictable jitter. Because these network mechanisms directly explain why standard Ethernet cannot meet strict real-time constraints, both statements are true and logically linked.

41. (C) 24
The IEEE four-eight-eight interface, commonly known as the General Purpose Interface Bus, utilizes a twenty-four-conductor cable. These lines are divided into eight bi-directional data lines for byte-parallel transfer, five general bus management lines, three handshake lines to coordinate communication between devices of different speeds, and eight ground return lines for shielding.

42. (B) Talker
In the GPIB architecture, devices are assigned specific operational roles to manage bus traffic. A talker is designated by the controller to place data onto the parallel bus, allowing it to send measurements or status information to other devices. Only one device can act as an active talker at any single moment to prevent conflicts.

43. (A) DAV, NRFD, NDAC
The three-wire handshake in IEEE four-eight-eight ensures reliable asynchronous communication. The data valid line is driven by the source to indicate stable data is on the bus. The not ready for data and not data accepted lines are managed by receiving devices to coordinate transmission, ensuring that data is transferred only when all listeners are ready.

NODIA

44. (C) Standard Commands for Programmable Instruments
SCPI stands for Standard Commands for Programmable Instruments, defining a uniform set of textual commands for controlling test and measurement devices. This standard ensures interoperability by using a consistent syntax regardless of the manufacturer, simplifying software development since commands for tasks like measuring voltage or frequency remain identical across different instruments.

45. (A) P-4, Q-1, R-2, S-3
Display technologies rely on distinct operational methods to construct images. Passive matrix LCDs use a simple grid of conductive traces, whereas active matrix designs integrate a dedicated transistor at each pixel for faster response. Plasma displays utilize ionized gas pockets to excite colored phosphors, and projection systems employ optical lenses to project images onto screens.

46. (C) High-frequency repetitive signals that exceed the real-time sample rate
Equivalent-time sampling allows digital storage oscilloscopes to capture high-frequency repetitive signals that exceed the converter's real-time sampling rate. By acquiring a few samples during each successive cycle of the periodic waveform and reconstructing them over time, the system builds a highly accurate representation of the signal without requiring an ultra-high-speed digitizer.

47. (B) Maintain a high sample rate over a long timebase setting
The memory depth of an oscilloscope specifies the maximum number of samples stored during an acquisition cycle. When a user selects a slow timebase to observe a long event, a shallow memory forces the instrument to reduce its sampling rate to avoid running out of storage. A deep memory prevents this, maintaining high-frequency detail.

48. (D) The ability to resolve closely spaced frequency components in the spectrum
In a swept-tuned spectrum analyzer, the resolution bandwidth filter is the intermediate frequency filter that determines the frequency resolution. A narrower filter bandwidth allows the analyzer to distinguish between two closely spaced spectral components, but requires a slower sweep rate to allow the internal circuits to settle and prevent amplitude measurement errors.

49. (A) Capture time-domain data and mathematically transform it to the frequency domain
Fast Fourier transform analyzers process signals by digitizing the incoming time-domain waveform using an analog-to-digital converter. The instrument then applies mathematical algorithms to convert this digital data into a frequency-domain spectrum. This process enables real-time signal analysis and transient capture, whereas swept-tuned analyzers must sequentially scan across a frequency range.

50. (A) I and II
Logic analyzers are digital troubleshooting instruments optimized for multi-channel digital systems. In timing mode, they sample inputs asynchronously using an internal clock to capture transition intervals. In state mode, they operate synchronously using the clock of the system under test. They assess binary states rather than resolving precise, continuous analog voltage levels.

51. (A) Both amplitude and phase properties (S-parameters) of high-frequency networks
Vector network analyzers are high-frequency instruments designed to measure the reflection and transmission coefficients of electrical networks. By injecting known RF signals and measuring both the amplitude and phase of the resulting waves, they characterize scattering parameters, which is essential for designing and tuning high-frequency components, antennas, and transmission lines.

52. (D) Are limited by mechanical inertia and offer poor long-term data manipulation
Analog chart recorders rely on mechanical pens to draw physical traces on moving paper. Their frequency response is severely limited by the mechanical inertia of the pen assembly, preventing them from capturing fast transients. Furthermore, paper charts are cumbersome to store, index, and analyze compared to modern digital storage systems.

53. (B) Reconstruction smoothing filtering
The output of a digital-to-analog converter contains undesirable high-frequency steps and quantization noise, resulting in a staircase-like appearance. A reconstruction or smoothing low-pass filter must be placed immediately after the converter to suppress these high-frequency components. This process smooths out transitions, restoring a continuous and accurate analog waveform.

54. (C) Low-resistance and high OFF-resistance
An ideal analog multiplexer must route signals with minimal distortion and leakage. It requires a very low on-resistance to prevent signal attenuation and phase shifts when a channel is active. Conversely, it must maintain an extremely high off-resistance to prevent signals from inactive channels from leaking through, which minimizes crosstalk and measurement errors.

55. (B) I, II and III
Sample and hold specifications govern the timing and accuracy of the acquisition process. The acquisition time must be shorter than the sampling period to allow proper settling. Aperture time represents the switch-opening uncertainty, while dielectric absorption causes hold voltages to drift toward previous levels. Droop rate is highly temperature-dependent due to semiconductor leakage.

56. (A) It introduces a memory effect where hold voltage creeps back to a prior state
Significant dielectric absorption inside a hold capacitor creates a memory effect where the dielectric material retains some polarization from previous charge states. When the circuit switches to the hold state, this retained charge slowly migrates back into the electrodes, causing the held voltage to drift toward prior levels and introducing measurement errors.

57. (C) 10 mV
The voltage value of one least significant bit determines the resolution of a converter. For a ten-bit system, the reference voltage is divided into two raised to the tenth power, which

Click Here to Buy book on Amazon

electrostatic coupling from nearby electrical noise sources.

116. (D) Statistically independent and uncorrelated with respect to each other
The root sum square method is a statistical approach used to calculate the total uncertainty of a measurement system. This mathematical technique is valid under the assumption that the individual error sources are completely independent and uncorrelated. This assumption prevents overestimating the total error, which would occur if the errors were summed algebraically.

117. (D) 100,000
Common-mode rejection ratio is a measure of an amplifier's ability to reject unwanted signals common to both input leads relative to the differential signal. Decibels are calculated using a logarithmic scale. A rejection ratio of one hundred decibels corresponds to a voltage gain ratio of ten to the power of five, which is one hundred thousand.

118. (C) Single-ended grounded
A single-ended grounded input configuration is highly susceptible to ground loop errors. In this setup, the signal is referenced to the system's local ground. If the signal source is also connected to a separate ground point, any potential difference between these two grounds creates a current loop that injects noise directly into the measurement path.

119. (D) Between the analog multiplexer and the input of the ADC
In a multi-channel data acquisition system, the programmable gain amplifier is placed between the analog multiplexer and the analog-to-digital converter. This positioning allows the amplifier to dynamically scale the selected channel's signal to match the converter's full-scale input range, optimizing the system's dynamic range and resolution for each input channel.

120. (B) 10 µs
The duration a digital-to-analog converter holds a specific voltage level is the reciprocal of its update rate. If a converter updates its analog output at a maximum rate of one hundred thousand samples per second, the minimum duration for each step is calculated as one divided by one hundred thousand, which equals exactly ten microseconds.

121. (B) Capture and record data that occurred immediately prior to the trigger event
Hardware triggering with a pre-trigger buffer allows a data acquisition system to capture events that occurred before the trigger signal. The system continuously digitizes and stores input signals in a circular buffer. When the trigger event is detected, the system retains the pre-trigger data alongside the post-trigger data, which is useful for analyzing transient faults.

122. (B) Graphical block diagrams and software front panels interfacing with generic DAQ hardware
Virtual instruments in software environments utilize graphical programming to replace physical laboratory equipment. These applications combine software front panels, which feature interactive controls and displays, with underlying graphical block diagrams that manage data processing. This software-defined approach interfaces with generic digitizing hardware to perform measurements, visualization, and analysis on standard computers.

123. (A) Non-volatile solid-state Flash memory
Standalone data loggers deployed in remote environments require reliable, low-power storage that retains data during power outages. Non-volatile solid-state flash memory is ideal for these applications because it has no moving parts, resists mechanical shock, consumes minimal power, and retains stored measurements indefinitely without requiring a continuous backup power supply.

124. (C) Physical thickness
PCMCIA cards were a standard expansion interface used in early portable computers and data loggers. The standards defined Type one, Type two, and Type three cards, which used an identical sixty-eight-pin connector but differed in physical thickness. Type one cards were the thinnest, while Type three cards were the thickest to accommodate mechanical drives.

125. (D) To indicate to the DTE that a valid connection to the remote device has been established
In the RS-two-thirty-two standard, the data carrier detect line is a control signal used by data communications equipment, such as a modem, to signal the data terminal equipment.

NODIA

combines multiple high-speed, low-resolution bits into high-resolution digital words.

68. (D) Parts per million per degree Celsius of temperature
Thermal drift describes how the electrical parameters of high-precision components, such as reference voltages and resistor networks in hybrid converters, shift with changes in ambient temperature. This critical performance variation is quantified in parts per million per degree Celsius, indicating the fractional change in the parameter for each degree of temperature deviation.

69. (B) It causes a direct proportional error in the converted digital output code values
The reference voltage establishes the full-scale range and individual step sizes of both digital-to-analog and analog-to-digital converters. Any instability, noise, or thermal drift in this reference directly alters the scaling factor of the conversion. This instability translates into proportional measurement errors in the output codes, even if the input signal remains perfectly stable.

70. (A) I, II, III, IV
Signals flow sequentially through a data acquisition system, from physical origin to digital representation. Non-linearity originates first at the sensor. The signal then travels through cabling, where it is susceptible to ground loop interference. Next, the signal is amplified and conditioned, introducing amplifier offset drift, before final digitization by the converter introduces quantization errors.

71. (D) High-frequency capacitive coupling and electrostatic interference
Metallic shielding in signal cables acts as a Faraday cage to protect delicate analog signals from external electric fields. Grounding the shield provides a low-impedance path that diverts stray capacitive currents to ground. This shielding is highly effective at blocking high-frequency capacitive coupling and electrostatic interference from nearby power lines or digital circuitry.

72. (A) Grounding the system at a single common point
Ground loops occur when a measurement system is grounded at multiple physically separate points, creating closed conductive loops susceptible to stray magnetic fields and potential differences. These loops introduce noise into analog signal lines. Establishing a single star-ground point ensures that all components share a common reference, preventing loop currents from corrupting measurements.

73. (B) Reject common-mode voltages appearing on both input lines simultaneously
Differential input configurations utilize two signal lines, measuring the voltage difference between them rather than referencing a single line to ground. Noise and common-mode voltages that affect both conductors equally are rejected by the differential amplifier. This capability makes differential inputs highly effective at preserving signal integrity over long cable runs in noisy environments.

74. (B) Settling time
The maximum update rate of a digital-to-analog converter in an arbitrary waveform generator is limited by how quickly the output can change between states. The settling time defines the interval required for the analog output to reach and remain within a specified error band after a new code is applied, restricting the maximum generation frequency.

75. (A) Both A and R are true and R is the correct explanation of A.
Programmable gain amplifiers expand the dynamic range of data systems by adjusting their gain to match the signal level. For small signals, increasing the gain ensures they span more of the converter's input range, minimizing the relative effect of quantization noise. Because this adaptive scaling directly improves dynamic range, both statements are true and logically related.

76. (C) The unwanted signal coupling from an inactive off-channel to the multiplexer output
Crosstalk in multi-channel analog multiplexers refers to the undesirable transfer of signal energy from unselected channels to the active output. This signal leakage is caused by parasitic capacitive and inductive coupling between adjacent internal switches and signal traces on the silicon chip, resulting in measurement errors on the active channel when adjacent inputs change.

Downloaded from www.pdf.tube

response in the passband. This is achieved by utilizing a filter with a flat group delay, such as a Bessel filter. This characteristic ensures that all frequency components experience the same time delay, preventing phase distortion in the filtered output.

97. (A) Charge injection
When an analog multiplexer switches channels, the digital control signals transition rapidly. This voltage swing couples through the parasitic gate-to-source capacitance of the internal solid-state switches, injecting a small packet of charge into the analog signal path. This charge injection produces a transient error voltage on the hold capacitor, compromising measurement accuracy.

98. (C) Significantly higher than the active source impedance
To prevent loading errors when measuring a signal source with high output impedance, the input stage of the multiplexer must exhibit a much higher impedance. A high input impedance minimizes the current drawn from the source, reducing the voltage drop across the source resistance and ensuring that the digitized voltage matches the actual sensor voltage.

99. (A) A system combining a PC, external analog front-end modules, and modular digitizers
A hybrid data acquisition system integrates distinct hardware platforms to perform measurement tasks. Typically, this setup combines a standard computer with external analog front-end signal conditioning modules and high-speed modular digitizers. This hybrid approach leverages the processing power of the computer alongside specialized analog circuitry, providing a flexible and high-performance measurement system.

100. (A) Both A and R are true and R is the correct explanation of A.
In a multiplexed system, the sample and hold circuit must be given sufficient time to track and settle on the selected channel's voltage before digitization begins. If the converter starts conversion prematurely during the acquisition phase, it will digitize an unsettled voltage, resulting in inaccurate data. Therefore, both statements are true and logically connected.

101. (B) Capacitor soakage
Dielectric absorption is an electrical phenomenon where a capacitor does not discharge fully or retain its charge perfectly due to the polarization of its dielectric material. This effect is commonly referred to as capacitor soakage. In sample and hold circuits, this soakage causes the held voltage to drift toward its previous charge level, introducing measurement errors.

102. (C) There is a 1 ns timing uncertainty in the actual instant the sample is taken
Aperture time represents the small, finite interval required for a sampling switch to transition from the sample state to the hold state. An aperture time of one nanosecond indicates that there is a one-nanosecond timing uncertainty regarding the exact moment the analog voltage is captured, which can introduce amplitude errors when measuring fast-slewing signals.

103. (C) 16 times finer
An eight-bit digital-to-analog converter resolves signals into two hundred fifty-six steps, whereas a twelve-bit converter divides the same reference voltage into four thousand ninety-six steps. Because four thousand ninety-six is exactly sixteen times larger than two hundred fifty-six, upgrading to a twelve-bit converter makes the step size, or resolution, sixteen times finer.

104. (A) The strict tolerance and matching requirements of the internal passive resistors
While the R-two-R ladder architecture requires only two resistor values, achieving high resolution is still limited by manufacturing tolerances. As the resolution increases, the internal resistors must be matched with extreme precision to prevent differential non-linearity and missing codes. Even slight mismatches in resistor values can degrade the accuracy and linearity of the converter.

105. (A) P-2, Q-4, R-1, S-3
Different converter architectures have distinct trade-offs. Flash converters consume significant power and require a large die area for high resolutions. Successive approximation register designs require N clock cycles, meaning speed scales inversely with resolution. Dual-slope integrating converters have slow conversion speeds, and sigma-delta converters introduce signal latency due to their digital decimation filtering stages.

NODIA

87. (D) Hierarchical text-based tree structure defined by standards
SCPI commands are constructed using a hierarchical, text-based tree structure that groups related instrument functions into logical branches. Users navigate this tree using colon-separated keywords to build commands, such as setting a measurement parameter. This standardized format makes the command set highly readable and consistent across different types of programmable instruments.

88. (A) The lack of a dedicated switching transistor at each pixel structure
Passive matrix LCDs rely on a grid of intersecting row and column electrodes to activate pixels, lacking dedicated switching transistors. This configuration suffers from slower response times and lower contrast due to sneak-path voltages and slow liquid crystal transitions. Active matrix displays resolve these issues by using thin-film transistors to control each pixel individually.

89. (B) Tiny pockets of gas that emit ultraviolet light when ionized, which excites phosphors
Plasma displays generate images using a grid of microscopic cells containing noble gases. When a voltage is applied to a cell, the gas ionizes into a plasma state and emits ultraviolet light. This UV radiation strikes the phosphor coating on the inside of the cell, exciting the phosphors to emit visible red, green, or blue light.

90. (B) I, II and III
Digital storage oscilloscopes utilize real-time sampling to digitize waveforms in a single acquisition pass. Their memory depth determines how long they can capture data while maintaining a high sampling rate. Additionally, they feature advanced triggering modes to isolate specific pulse widths. They rely on high-speed digitizers rather than swept-tuned local oscillators to capture signals.

91. (A) The sample rate must be drastically reduced, risking aliasing
The relationship between memory depth, sample rate, and timebase in an oscilloscope is highly interdependent. When a user selects a slow timebase to view a long-duration event, a shallow memory depth forces the instrument to reduce its sampling rate. This reduction in speed increases the risk of aliasing, as high-frequency components can fold down into the measurement.

92. (C) Provided externally by the target clock of the system under test
When a logic analyzer is configured for state analysis, it operates synchronously to capture the logical states of a digital system. In this mode, the sampling clock is not generated internally. Instead, it is provided externally by the clock signal of the system under test, ensuring that data is sampled precisely when valid states occur on the bus.

93. (D) The amplitude properties (magnitude) of transmission or reflection signals without phase information
Scalar network analyzers are RF instruments designed to make measurements of the transmission and reflection characteristics of high-frequency components. Unlike vector network analyzers, which measure both magnitude and phase, scalar analyzers measure only the amplitude properties of signals. This makes them simpler and more cost-effective for applications where phase relationship information is not required.

94. (C) Storing high-bandwidth analog signals for later playback and off-line signal analysis
In legacy instrumentation systems, magnetic tape recorders were widely used to record high-bandwidth analog signals. These devices recorded continuous voltage waveforms from transducers onto magnetic tape. This stored data could later be played back at different speeds for detailed offline analysis, providing a reliable method for capturing transient events before high-speed digital storage became common.

95. (A) I, III and IV
Transducers convert physical parameters into electrical signals, which then pass through filtering stages to restrict the bandwidth before digital sampling. Multiplexers allow a single analog-to-digital converter to handle multiple input channels sequentially. Because signal conditioning involves processes beyond amplification, and input digital-to-analog converters are not always required, these three statements are correct.

96. (D) A flat group delay response (e.g., Bessel filter)
To preserve the phase relationships and waveshapes of complex analog signals, an anti-aliasing filter must provide a linear phase

Click Here to Buy book on Flipkart

77. (D) -5 V to +5 V
A bipolar analog input configuration is designed to acquire signals that swing both positive and negative relative to a common ground. This differs from unipolar ranges, which only accept single-polarity voltages. A typical bipolar range, such as minus five to plus five volts, is ideal for interface circuits connected to AC sensors or bidirectional transducers.

78. (C) Controlling external relays and reading physical switch logic states
Digital input and output lines in data acquisition systems handle binary control and monitoring tasks. These digital lines transfer low-voltage logic signals to operate solid-state or electromagnetic relays, control status indicators, and interface with binary actuators. They are also used to read the states of physical switches, limit sensors, and industrial proximity alarms.

79. (B) High frequencies
The direct frequency measurement technique counts incoming signal pulses over a precise, predefined gating interval. This method is highly accurate for high-frequency signals because a large number of cycles are counted during the gate period, reducing fractional quantization errors. For low-frequency signals, measuring the period of the input wave is typically preferred to maintain accuracy.

80. (A) P-1, Q-4, R-2, S-3
Data logger architectures are defined by their operating methods and configurations. PC-based systems rely entirely on a host computer for control and processing, whereas standalone loggers run autonomously on battery power. Distributed loggers utilize remote, networked nodes for flexible data collection, and PCMCIA-based loggers feature portable memory cards for data storage in legacy systems.

81. (A) Start bit
In asynchronous serial communication, the transmission line remains in a high state when idle. To signal the start of a character, the transmitter sends a start bit by pulling the line low for one bit period. This transition alerts the receiver's internal clock to synchronize and begin sampling the incoming data bits at the designated baud rate.

82. (C) Differential, balanced voltage
The RS-four-eight-five standard utilizes a balanced, differential signaling scheme to transmit digital data. This method sends the signal across a pair of conductors as a voltage difference, where one line carries the inverted version of the other. This differential configuration allows receivers to reject common-mode noise, enabling reliable communication over long distances in noisy industrial environments.

83. (A) A half-duplex arbitration scheme allowing one node to drive the bus at a time
Because a multi-drop RS-four-eight-five network shares a single differential line among multiple nodes, a control mechanism must prevent transmission conflicts. The system operates in half-duplex mode using an arbitration or master-slave protocol, ensuring that only one transmitter drives the bus at any single moment while other nodes remain in a high-impedance listening state.

NQDIA

84. (D) Minimizing latency is more important than absolute packet reliability and order
In remote data acquisition, the User Datagram Protocol is often preferred over TCP when real-time throughput is critical. Unlike TCP, UDP does not require connection handshakes, packet ordering, or retransmissions, which minimizes transmission overhead and latency. This makes UDP ideal for continuous streaming applications where receiving the latest sample quickly is more important than recovering lost packets.

85. (B) I and II
The IEEE four-eight-eight standard, or General Purpose Interface Bus, is a rugged parallel bus designed for laboratory instrumentation. It features an eight-bit parallel data bus for byte-transfer, and supports connecting up to fifteen instruments on a single physical bus. It utilizes electrical cables with twenty-four pins rather than fiber optics for its interconnections.

86. (C) Interface Clear
The interface clear line is a dedicated management line on the IEEE four-eight-eight bus. When asserted by the system controller, it immediately halts all active bus communications and resets the interface circuitry of all connected instruments to a known, idle state. This function allows the controller to regain control of the bus during communication lockups.

106. (B) -0.5 LSB and +0.5 LSB
In an ideal analog-to-digital converter, the quantization process rounds the continuous input voltage to the nearest discrete digital level. This rounding mechanism ensures that the maximum difference between the actual analog input and the digitized representation is strictly bounded between minus zero point five and plus zero point five of a least significant bit.

107. (A) The maximum number of complete conversions performed per second
The throughput rate of an analog-to-digital converter defines its continuous digitizing speed in a measurement system. This parameter specifies the maximum number of complete analog-to-digital conversions the device can perform and output per second, and is determined by both the core conversion time and any required multiplexer settling or overhead delays.

108. (C) The maximum deviation of the actual transfer function from the ideal straight line
Integral non-linearity is a key static specification that measures the overall linearity of a converter. It is defined as the maximum deviation of the actual transfer function from an ideal straight line, after correcting for offset and gain errors. This parameter quantifies the distortion introduced by the converter across its entire operating range.

109. (D) SAR ADC
A successive approximation register converter uses a binary search algorithm to digitize analog inputs. The internal controller sequentially tests each bit of the digital output, starting with the most significant bit. By comparing the input voltage against the output of an internal digital-to-analog converter, the system determines whether each bit should be set or cleared.

110. (A) Both A and R are true and R is the correct explanation of A.
Flash converters are rarely manufactured with resolutions above twelve bits because their parallel architecture requires a large number of components. The comparator count doubles with each additional bit of resolution, leading to high power dissipation and a massive silicon die area. Because this hardware scaling limit directly restricts resolution, both statements are true and logically related.

111. (B) Setting the integration time to a multiple of the noise wave period
Dual-slope integrating converters reject periodic AC noise, such as fifty or sixty hertz power-line interference, through their integration process. By setting the integration period of the input signal to match a multiple of the noise signal's period, the positive and negative halves of the noise waveform average out to zero, eliminating the interference from measurements.

112. (D) Low-pass filter for the input signal and high-pass filter for the quantization noise
The feedback modulator in a sigma-delta converter shapes the noise spectrum of the digitization process. It acts as a low-pass filter for the analog input signal, preserving low-frequency data. Simultaneously, it functions as a high-pass filter for the quantization noise, pushing the noise power into higher-frequency regions where a digital filter can remove it.

NODIA

113. (A) They allow mixing of different optimized semiconductor technologies (e.g., CMOS and Bipolar) in one package
Multi-chip modules in hybrid converters allow designers to combine different optimized semiconductor technologies within a single package. For example, high-speed bipolar circuits can be integrated alongside low-power CMOS logic and high-precision resistor networks. This flexibility enables high-performance designs that are difficult or expensive to fabricate on a single, monolithic silicon chip.

114. (C) A deviation that is proportional to the input signal amplitude range
Gain error represents a slope deviation in the transfer function of a converter. Unlike offset error, which adds a constant shift across all codes, gain error causes a measurement deviation that scales proportionally with the amplitude of the input signal. This error is zero at the origin and reaches its maximum value near full scale.

115. (A) P-2, Q-3, R-4, S-1
Hardware noise reduction techniques utilize distinct physical principles to preserve signal integrity. Twisted-pair wiring cancels magnetic interference through its geometric layout, while optical isolation breaks electrical connections using light to transmit signals. Differential signaling subtracts common-mode noise present on two lines, and physical shielding blocks

135. (D) Better true black levels and wider viewing angles of pixels
In older instrumentation displays, plasma technology offered significant performance advantages over early LCD panels. Because plasma pixels are emissive light sources that can be turned completely off, they provided superior contrast with deep black levels. Additionally, this emissive nature enabled much wider viewing angles without color shifts or brightness degradation across the screen.

136. (A) The speed of the internal ADC
Real-time sampling in digital storage oscilloscopes requires direct, instantaneous digitization of the incoming analog signal. The maximum rate at which this process occurs is physically constrained by the conversion speed of the internal analog-to-digital converter. No other system component can exceed this hardware-defined limit, making it the primary bottleneck for real-time data acquisition.

137. (B) Glitch pulse triggering
Capturing transient, non-periodic anomalies such as brief noise spikes requires a specialized triggering mechanism. Glitch triggering enables the instrument to isolate pulses that are narrower than a user-specified duration threshold. This capability prevents standard edge triggers from being overwhelmed by normal signal transitions, ensuring that rare hardware anomalies are reliably captured and displayed.

138. (B) The maximum input signal level before distortion to the displayed average noise floor (DANL)
The dynamic range of a spectrum analyzer characterizes its ability to resolve widely different signal amplitudes simultaneously. It represents the ratio between the largest input signal that can be measured without generating internal distortion and the smallest detectable signal, which is limited by the displayed average noise floor. This parameter determines the measurement limits.

139. (A) Spectral leakage from finite sampling intervals
Performing a fast Fourier transform on finite time-domain records introduces spectral leakage because the signal is abruptly truncated at the boundaries. Applying windowing functions smooths these transitions toward zero at the limits of the observation window. This attenuation reduces the sidelobes in the frequency spectrum, preventing spectral energy from leaking into adjacent frequency bins.

140. (C) High asynchronous sample rate to capture timing and brief glitches
Timing logic analyzers operate using an independent, high-frequency internal clock to sample digital lines asynchronously. This high sampling resolution is critical for measuring precise time intervals, detecting race conditions, and capturing sub-clock transient glitches between state transitions. It prioritizes detailed timing verification over the functional state transitions of the target device clock.

141. (D) Linear electrical networks at high frequency ranges
Scattering parameters describe the electrical behavior of linear networks when subjected to high-frequency stimuli. Because physical voltages and currents become difficult to measure directly at radio and microwave frequencies, these parameters quantify the reflection and transmission properties of traveling waves. This methodology provides a comprehensive framework for characterizing high-frequency electronic circuits.

142. (C) Continuous analog recording
Traditional chart recorders capture dynamic physical parameters by continuously plotting analog voltage variations directly onto a moving paper medium. The mechanical plotting mechanism is directly driven by the incoming electrical signal without any digital discretization or sampling processes. This design achieves uninterrupted historical logging of slowly varying signals in real-time environments.

143. (B) Cold-junction compensation and low-level amplification
Thermocouples generate very small, millivolt-level analog voltages that require significant amplification to match the input ranges of standard digitizers. Additionally, because these sensors measure temperature differentials relative to the connection point, cold-junction compensation must be applied to correct for the reference junction temperature. These two steps ensure highly accurate thermal measurements.

Downloaded from www.pdf.tube

When asserted, this line indicates that the local modem has established a valid connection and is receiving a carrier signal from the remote modem.

126. (B) 15 meters (50 feet)
The RS-two-thirty-two standard utilizes single-ended signaling, which is highly susceptible to noise and ground potential differences over long cable runs. Consequently, the standard specifies a maximum reliable cable length of approximately fifteen meters, or fifty feet, at moderate baud rates. Using longer cables increases the risk of data corruption due to signal attenuation.

127. (B) Differential voltage transmission across a shielded twisted pair
The RS-four-eight-five standard achieves long-distance communication and high noise immunity by using differential signaling over a balanced twisted pair. This configuration transmits data as the voltage difference between two lines, allowing the receiver to reject common-mode noise. This enables reliable data transmission over distances up to twelve hundred meters in electrically noisy environments.

128. (C) 1200 meters
The RS-four-eight-five standard is optimized for long-distance industrial networks. At lower baud rates, where high-frequency attenuation and cable delays are less critical, the maximum recommended physical length for a differential bus segment is twelve hundred meters, or four thousand feet. Achieving this distance requires proper cable termination to prevent signal reflections.

129. (A) The Sequence Number field located within the TCP packet header structure
Ethernet networks route data packets independently, which can cause them to arrive out of order at their destination. The transmission control protocol manages this by assigning a unique sequence number to each packet header. The receiving device uses these sequence numbers to reassemble the data stream in the correct order before passing it to the application.

130. (C) Network traffic congestion and non-deterministic packet routing paths in switches
In high-speed remote data acquisition systems connected via Ethernet, communication bottlenecks are primarily caused by network traffic congestion and non-deterministic routing. Because standard Ethernet switches route packets dynamically based on active traffic, the time delay between transmissions can vary. This latency and jitter can disrupt real-time synchronization in distributed measurement applications.

131. (A) Through a 3-wire asynchronous hardware handshake
The IEEE four-eight-eight parallel bus coordinates data transfers between devices of varying speeds using a three-wire asynchronous hardware handshake. This process ensures that the active talker does not transmit a new byte until all active listening devices have successfully accepted the previous one, preventing data loss without requiring a synchronized system clock.

NODIA

132. (D) When the slowest Listener has accepted it
The asynchronous three-wire handshake used in the GPIB protocol is designed to accommodate devices with different processing speeds. During a data transfer, the active talker must wait for all addressed listeners to signal that they have accepted the byte. Consequently, the transfer is complete only when the slowest active listener has asserted its ready line.

133. (B) Resets the entire instrument back to a known default state
The SCPI command reset is a standardized command recognized by programmable instruments. When this command is sent, the instrument immediately aborts any active measurements, clears pending errors, and restores its settings to a known factory-default state. This initialization step is commonly used at the start of automated testing programs to ensure consistent operation.

134. (C) Thin-Film Transistors (TFTs) integrated directly onto the glass for each pixel
Active matrix LCDs achieve high refresh rates and superior contrast by integrating a dedicated thin-film transistor at each pixel location on the glass substrate. These transistors act as switches that rapidly charge and hold the voltage across individual liquid crystal cells, preventing charge leakage and crosstalk, resulting in a sharper and faster display response.

equals one thousand twenty-four discrete levels. Dividing a reference voltage of ten point two four volts by this value yields exactly ten millivolts.

58. (B) The internal output amplifier slew rate and parasitic capacitance
The settling time of a digital-to-analog converter is the time required for the output to stabilize within a specified error band after a code transition. This parameter is heavily influenced by internal hardware limits, specifically the slew rate of the output buffer amplifier and the parasitic capacitances present in the ladder network and output nodes.

59. (A) Minimum pin count and low power
Serial digital-to-analog converter architectures are highly advantageous for applications with strict spatial and power constraints. By transmitting digital inputs sequentially over a simple serial interface, they require far fewer physical pins than parallel converters. This simplified layout reduces package size, lowers manufacturing costs, and minimizes overall power consumption in portable devices.

60. (C) III and V
Quantization error is an inherent limitation of dividing a continuous signal into discrete steps and cannot be eliminated by shielding. Furthermore, an N-bit converter possesses two raised to the power of N distinct quantization levels, making statements asserting otherwise incorrect. Proper calibration and high-resolution configurations are needed to address these digitization limits.

61. (D) Left or right uniformly across all codes
An offset error in an analog-to-digital converter shifts the entire transfer function uniformly. If a system exhibits a constant positive offset, every digital code transition occurs at a lower input voltage than ideal. This results in a parallel shift of the entire conversion curve to the left or right, affecting all measurements equally.

62. (C) The output of an internal DAC
A successive approximation register converter uses a binary search algorithm to digitize analog inputs. During this process, the internal register controls a digital-to-analog converter to generate a sequence of reference voltages. An internal comparator continuously compares these reconstructed voltages against the sampled input signal to determine each bit of the digital output.

63. (C) N cycles
The successive approximation register architecture evaluates each bit of the digital output sequentially, starting from the most significant bit down to the least significant bit. Because the binary search algorithm processes exactly one bit per clock period, a basic converter requires N clock cycles to complete a conversion for an N-bit output.

64. (C) $2^N - 1$
Flash converters achieve ultra-fast speeds by comparing the analog input voltage against a set of reference levels simultaneously. This parallel architecture requires a divider network with a separate comparator for every possible transition step. For an N-bit resolution, the design must incorporate two raised to the power of N, minus one, individual comparators.

65. (B) Anti-aliasing Filter → Integrator → Decimation Filter
In a sigma-delta converter, the analog signal first passes through a simple anti-aliasing filter to remove high-frequency noise. The signal then enters the modulator stage, where an integrator accumulates the difference between the input and feedback. Finally, the high-rate digital stream is processed by a decimation filter to lower the sampling rate and increase resolution.

66. (C) Quantization noise power is spread over a wider frequency band in the spectrum
Oversampling involves sampling the analog signal at a frequency significantly higher than the Nyquist rate. While the total quantization noise power remains constant, sampling faster spreads this noise power across a much wider frequency band. This reduces the noise density in the lower-frequency band of interest, allowing digital filtering to remove the out-of-band noise.

67. (A) Decreasing the sampling rate while increasing the bit resolution digitally
Decimation is a digital processing stage in sigma-delta converters that follows high-rate modulation. This process filters the high-frequency quantization noise out of the bitstream, then systematically discards redundant samples to reduce the sampling rate to the Nyquist standard. This filtering and downsampling

Click Here to Buy book on Amazon

144. (D) High inter-channel crosstalk and settling time errors
Multiplexing signals with highly mismatched source impedances can cause significant measurement errors during rapid channel transitions. High source impedance increases the time constant required to charge the parasitic capacitance of the multiplexer bus. This delay prevents the signal from fully stabilizing before digitization, leading to severe settling time errors and inter-channel crosstalk.

145. (A) It prevents channel short-circuits during transitions
In multiplexed systems, switching between multiple input channels must be handled carefully to avoid connecting two active sources together. The break-before-make control sequence ensures that the currently active analog switch is completely disconnected before the next channel switch is closed. This timing safeguard prevents harmful momentary short-circuits between different input signal sources.

146. (C) 0.1% or 0.01% of the full-scale range
High-accuracy data acquisition systems require the multiplexer output to stabilize extremely close to the true input value before digitization. Consequently, settling time is typically specified using narrow error bands representing tiny fractions of the full-scale range. Achieving stability within these stringent limits ensures that consecutive channel readings remain free from residual voltage pollution.

147. (A) It holds the fast-changing analog input during conversion
Analog-to-digital converters require a stable, unchanging input voltage during their conversion cycle to prevent measurement errors. A sample and hold amplifier rapidly tracks the incoming waveform and then maintains a constant voltage level on an internal storage capacitor. This temporary freezing of the signal prevents dynamic errors during the digitization process.

148. (D) A low-leakage capacitor utilizing Teflon dielectric
Droop rate represents the gradual discharge of the held voltage during the hold phase of a sample and hold circuit. To preserve signal integrity, the storage capacitor must exhibit extremely low leakage characteristics. High-quality dielectric materials prevent charge from escaping through the component itself, keeping the stored voltage stable while the analog-to-digital converter performs its measurement.

149. (A) $\frac{5\,V}{65536}$
The resolution of a digital-to-analog converter represents the smallest change in the analog output voltage corresponding to a single-step change in the digital code. For a converter containing sixteen bits, the total number of discrete output levels is calculated as two raised to the sixteenth power. Dividing the full-scale reference voltage by this total yields the step size.

150. (C) Scale a varying analog reference by digital input
Multiplying digital-to-analog converters are designed to accept an external analog reference voltage that can vary dynamically over a wide range. The device continuously multiplies this changing analog reference signal by the applied digital input code. This unique capability enables the system to function as a digitally controlled analog attenuator, gain controller, or waveform modulator.

151. (D) The applied analog reference voltage
In a standard non-multiplying digital-to-analog converter, the maximum achievable output voltage is directly determined by the magnitude of its reference voltage. This reference establishes the baseline scale against which all digital codes are converted. Consequently, the output cannot exceed this hardware-defined electrical boundary, which serves as the fundamental scaling factor for the entire device.

NODIA

152. (C) $2^{N-1} \times R$
Parallel weighted-resistor digital-to-analog converters use binary-weighted resistors to scale currents for each bit. Since each successive bit must contribute exactly half the current of the preceding bit, the resistance values must double for each step from the most significant bit to the least significant bit. For an N-bit converter, the final scaling factor yields this relationship.

153. (B) A low-pass filter
Pulse-width modulation represents analog values using the duty cycle of a high-frequency digital square wave. To convert this rapid switching signal into a steady, continuous analog voltage, an external low-pass filter must be used. This

filter removes the high-frequency switching components and carrier harmonics, leaving only the average direct-current voltage level.

154. (C) 40 kHz
The sampling theorem dictates that a continuous-time signal can only be fully reconstructed without distortion if it is sampled at a rate strictly greater than twice its highest frequency component. For a signal with a maximum frequency of twenty kilohertz, doubling this limit establishes a minimum sampling threshold of forty kilohertz to prevent aliasing.

155. (A) 500 Hz
Sampling a signal below the Nyquist rate causes frequency folding, creating unwanted low-frequency aliases. When a one-kilohertz sine wave is sampled at one and a half kilohertz, the signal violates the sampling theorem. The resulting alias frequency is calculated as the absolute difference between the sampling frequency and the input frequency, which yields five hundred hertz.

156. (C) Missing codes
Monotonicity requires that the digital output of an analog-to-digital converter increases or remains constant as the analog input increases. If the transfer function is non-monotonic, the converter may output a lower digital code for a higher analog voltage. This behavior typically leads to missing codes, where certain digital output states are never produced.

157. (D) total time required for acquisition and conversion
The throughput rate of an analog-to-digital converter represents the speed at which it can process sequential samples. In a traditional non-pipelined architecture, each sample must complete the entire acquisition phase and the subsequent digitization phase before another can begin. Therefore, the maximum throughput rate is mathematically the inverse of the combined acquisition and conversion times.

158. (C) Faster than a single clock period of the algorithm
Successive approximation converters resolve each bit of resolution sequentially over a series of clock cycles. During each cycle, the internal digital-to-analog converter must output a voltage that the comparator compares against the input signal. The converter must fully stabilize within a single clock period to ensure accurate comparisons and prevent bit decision errors.

159. (B) Fixed and constant
Dual-slope integrating converters utilize a two-step integration process to convert analog signals. During the first phase, the input voltage is applied to the integrator for a fixed and predetermined time interval. Because this integration time is constant, the peak charge accumulated on the integration capacitor remains directly proportional to the average value of the input signal.

160. (D) A known reference voltage
In the second phase of a dual-slope conversion, the integrator is connected to a reference voltage of opposite polarity. The capacitor then discharges back to zero at a constant, known rate determined by this reference. The time taken to reach zero is measured digitally, allowing the system to calculate the input voltage with high precision.

161. (A) An integrator, 1-bit ADC, and 1-bit DAC in feedback
A basic first-order sigma-delta modulator employs a negative feedback loop to shape quantization noise. The core structure comprises an analog integrating stage that accumulates the difference between the input signal and a feedback signal. This integrated value is digitized by a one-bit converter, whose output is fed back through a one-bit digital-to-analog converter.

162. (C) Pushes in-band quantization noise to higher frequencies
Sigma-delta modulators use high-rate oversampling combined with feedback integration to implement noise shaping. This architecture acts as a high-pass filter for quantization noise while leaving the lower-frequency input signal unaffected. By shifting the bulk of the quantization noise power out of the signal band into higher frequencies, subsequent digital filtering can easily eliminate it.

163. (A) Low static power dissipation and high integration density
Complementary metal-oxide-semiconductor technology is highly favored for manufacturing monolithic converters. This process offers extremely low static power consumption, which

Downloaded from www.pdf.tube

prevents thermal issues on the silicon die. Furthermore, its high integration density allows both complex digital control logic and precision analog switching elements to be co-located on a single, cost-effective integrated circuit.

164. (D) Isolating digital parts from the reference to limit thermal drift
High-resolution converters are highly sensitive to temperature fluctuations, which can introduce drift in critical components. In PCB layouts, digital circuitry can generate localized heat during high-speed switching. Thermally isolating these warm digital areas from the sensitive analog reference path prevents thermal gradients and drift, ensuring the absolute stability of the measurement baseline.

165. (B) Offset error
Offset error in a data acquisition system represents a constant shift in the transfer function that remains identical across all input levels. Unlike gain error, which scales proportionally with the amplitude of the signal, offset error introduces a uniform DC bias. This systematic offset persists even when the physical input to the system is exactly zero.

166. (B) 1 mV
To determine the change in voltage caused by thermal drift, the reference value is multiplied by the temperature coefficient and the temperature shift. A coefficient of five parts per million per degree Celsius across a twenty-degree span yields a fractional shift of one hundred parts per million. Applying this to a ten-volt reference produces a one-millivolt change.

167. (D) Both capacitive and inductive noise coupling
Shielded twisted pair cables provide comprehensive protection against external noise sources in measurement environments. The metallic outer shield acts as a Faraday cage to block capacitive electrostatic coupling. Simultaneously, twisting the internal signal wires ensures that any magnetically induced loop currents are balanced and cancelled out, effectively mitigating both forms of electromagnetic interference.

168. (A) A single point (typically at the DAS end)
Ground loops occur when a cable shield is grounded at multiple points with different electrical potentials, causing unwanted noise currents to flow. To eliminate this issue, the shield should be connected to ground at only one end, usually the data acquisition system. This arrangement blocks current flow while still providing electrostatic shielding along the cable.

169. (B) Optical isolation (Optocoupler)
Transmitting static direct-current signals across an isolation barrier requires a mechanism that does not rely on voltage transitions. While magnetic and capacitive isolation methods inherently require alternating current or modulated signals to transfer energy, optical isolation uses light. This allows optocouplers to transmit constant, static signals continuously without complex modulation and demodulation circuitry.

170. (C) 100
A programmable gain amplifier scales small input voltages to better match the full-scale range of a downstream converter. To determine the gain setting, the targeted output voltage is divided by the original input signal strength. Dividing one volt by ten millivolts yields a gain factor of exactly one hundred, which optimizes the measurement resolution.

NODIA

171. (A) Offset Binary
Offset binary is a digital coding format commonly used for bipolar analog signals. In this scheme, the minimum negative full-scale voltage corresponds to all zeros, while the maximum positive full-scale voltage corresponds to all ones. Zero volts is represented by the half-scale code, simplifying the digital interface with standard unipolar converters.

172. (C) The DAC settling time and maximum digital interface data rate
The speed at which a data acquisition output channel can generate new analog values depends on both digital and analog constraints. The digital interface must transfer the control data to the converter quickly. Subsequently, the converter's internal analog circuitry must physically stabilize at the new voltage level, making settling time and data rates the key bottlenecks.

173. (B) 2.4 V
Transistor-transistor logic standards define strict voltage thresholds to ensure reliable communication between digital components. Under typical operating loads, a device must output a minimum voltage to guarantee that

makes it highly practical for manufacturing high-resolution integrated circuits.

214. (C) Infinite bandwidth demands on reconstruction filters
Sampling at exactly the Nyquist rate places the signal and its aliases immediately adjacent to each other in the frequency spectrum. Separating these components during reconstruction would require an ideal filter with an infinitely sharp transition band. Since physical filters cannot achieve infinite roll-off, reconstructing the original signal under these conditions is highly problematic.

215. (D) $6.02N + 1.76$ dB
The signal-to-quantization-noise ratio of an ideal converter is determined by its resolution in bits. Each additional bit of resolution reduces the quantization noise power by a factor of four, which corresponds to a six decibel improvement. Adding the theoretical correction factor for a full-scale sine wave yields this standard formula.

216. (A) less than -1 LSB
Differential non-linearity measures the deviation of an analog-to-digital converter's step width from the ideal value of one least significant bit. If the step width is reduced to zero or becomes negative, the corresponding digital code can never be output by the device. This condition occurs when the DNL is less than negative one.

217. (B) It tracks the digital guess, updating it via comparator feedback
The successive approximation register implements a binary search algorithm to digitize analog signals. It starts by setting the most significant bit to one, creating a digital guess. It then uses feedback from an analog comparator to determine whether to keep or clear that bit, repeating this process sequentially for each bit.

218. (B) Inherent noise integration to reject line frequencies
While successive approximation converters offer much faster conversion speeds, dual-slope integrating converters provide superior noise immunity. By integrating the input signal over a fixed period, the integrator naturally averages out high-frequency noise and AC power line hum. This inherent integration capability makes them highly accurate for low-bandwidth, precision instrumentation applications.

219. (A) Precision, low-bandwidth instrumentation and audio applications
Sigma-delta converters combine high oversampling rates with digital filtering to achieve exceptionally high resolution. However, the extensive digital processing required limits their effective conversion bandwidth. Consequently, these converters are predominantly used in applications that demand high precision but moderate speeds, such as professional audio processing and low-frequency laboratory instrumentation.

220. (C) Digital low-pass filter
The modulator stage of a sigma-delta converter produces a high-rate, low-resolution bitstream. To convert this signal into a usable high-resolution output, a decimation filter is used. This digital low-pass filter removes high-frequency quantization noise that was shifted upward by the modulator, while simultaneously reducing the sample rate to the Nyquist frequency.

221. (D) Integrating trimmed passives and isolated domains on a single die
Monolithic manufacturing requires fabricating all components on a single silicon substrate. This makes it difficult to integrate high-precision, laser-trimmed passive components and maintain electrical isolation between sensitive analog and noisy digital domains. Hybrid packages avoid this challenge by using separate physical chips and substrates within a single enclosure.

222. (B) 0.05% (500 ppm)
Gain drift describes how the scale factor of a converter changes with temperature. Multiplying a drift rate of ten parts per million per degree Celsius by a fifty-degree temperature change yields a total variation of five hundred parts per million. Converting this value into a percentage results in a gain error of zero point zero five percent.

223. (B) Input bias currents and voltage mismatches in op-amps
Offset error in signal conditioning circuits introduces a constant DC voltage shift to the output. This error is primarily caused by internal imbalances within the operational amplifiers, such as input offset voltage mismatches and input bias currents flowing through external resistors. These factors create a parasitic voltage that persists even when the input is zero.

Click Here to Buy book on Flipkart

digital transitions reach these boundaries, the electrical energy reflects back along the wire. These reflections distort the incoming voltage levels, causing timing issues and severe data corruption that can render communication impossible.

184. (A) Connection-oriented and reliable
The transmission control protocol is designed to guarantee the delivery of data across networks. Before any data is sent, it establishes a formal connection between the sender and receiver. It monitors packet delivery, manages flow control, and automatically requests the retransmission of lost or corrupted packets, ensuring highly reliable, error-free data transfer.

185. (B) Lack of determinism from variable routing and collision handling
Standard Ethernet networks prioritize data integrity and throughput over timing precision. The underlying protocols use collision avoidance, retransmissions, and dynamic packet routing, which introduce variable propagation delays. This lack of determinism makes standard networks unsuitable for high-speed real-time control loops that require strict, predictable timing for safety and system stability.

186. (B) Parallel, multi-drop interface
The general purpose interface bus standard was designed to connect multiple laboratory instruments together using a single shared bus. It uses a parallel architecture to transmit eight data bits simultaneously, which provides higher throughput than early serial links. Its multi-drop capability allows a single controller to manage and communicate with several instruments.

187. (A) The final byte of a multi-byte message transfer
The end or identify control line in GPIB networks is used to manage message boundaries during data transfers. When a transmitting device sends the last byte of a data packet, it asserts this line to notify the listening devices that the transfer is complete. This hardware signal prevents the receiver from waiting for more data.

188. (C) Controller
In a GPIB instrument network, bus traffic must be actively managed to prevent data collisions and ensure orderly communication. The device designated as the system controller is responsible for directing all bus operations. It commands specific instruments to either transmit data as talkers or receive data as listeners, maintaining complete control over the network.

189. (D) Polarizing filter pair
Liquid crystal displays control light transmission by manipulating its polarization. The display assembly includes a pair of polarizing filters aligned at right angles to each other. The liquid crystal layer modifies the polarization of light passing through, determining how much light escapes the outer filter. This mechanism directly influences the viewing angle and contrast.

190. (C) Digital Light Processing
Digital Light Processing is a display technology widely used in high-performance projection systems for control rooms and theaters. It relies on an optical semiconductor chip containing millions of microscopic mirrors that tilt rapidly to reflect light toward or away from the screen. This micro-electromechanical system provides high brightness, contrast, and color accuracy.

191. (B) 1 millisecond
The maximum capture time of a digital storage oscilloscope is determined by its memory depth divided by its sampling rate. For a system with one million storage points operating at a sampling rate of one billion samples per second, dividing these two values yields a maximum continuous capture duration of exactly one millisecond.

192. (D) Sampling across multiple repetitions of a periodic signal
Equivalent-time sampling is a technique used to reconstruct high-frequency waveforms that exceed the real-time sampling rate of the oscilloscope's converter. It requires the input signal to be periodic and repetitive. By capturing a few samples during each repetition at slightly offset times, the instrument compiles these points to reconstruct the complete waveform.

193. (A) Inhibit triggering on complex waves for a set time
Trigger holdoff is an essential control feature in oscilloscopes used when analyzing complex, multi-peaked waveforms. It disables the trigger circuit for a user-specified duration immediately following a valid trigger event. This delay prevents the instrument from triggering prematurely on

Downloaded from www.pdf.tube

intermediate signal peaks, ensuring a stable display of complex or burst waveforms.

194. (C) Frequency domain
Unlike oscilloscopes that plot voltage variations over time, spectrum analyzers are designed to measure and display electrical signals in the frequency domain. The resulting display plots signal amplitude on the vertical axis against frequency on the horizontal axis, allowing engineers to analyze harmonics, spectral distortion, and spurious emissions with high precision.

195. (A) Lower the displayed noise floor and improve resolution, requiring a longer sweep time
Reducing the resolution bandwidth of a spectrum analyzer uses narrower intermediate-frequency filters. This allows the instrument to resolve closely spaced spectral peaks and reduces the total noise power reaching the detector, which lowers the displayed noise floor. However, narrower filters respond more slowly, requiring a longer sweep time to prevent amplitude errors.

196. (D) Fast Fourier Transform (FFT)
Digital spectrum analyzers collect discrete time-domain samples of an incoming signal and convert them into a frequency-domain spectrum. To perform this conversion in real-time, the instrument's processor utilizes the Fast Fourier Transform algorithm. This highly optimized mathematical process computes the discrete Fourier transform quickly, enabling real-time spectral analysis.

197. (B) Monitors multi-channel digital states via logic thresholds
While oscilloscopes measure and display continuous analog voltage levels with high vertical precision, logic analyzers are optimized for digital systems. They use voltage thresholds to simplify inputs into binary high or low states across dozens of channels simultaneously, allowing engineers to verify timing relationships and buses in digital circuits.

198. (C) Tracking microprocessor execution on active clock edges
State analysis is a synchronous operating mode where the logic analyzer samples data using the clock signal of the target system. This approach captures digital states exactly when they are valid, making it ideal for tracking microprocessor program execution, monitoring bus transfers, and verifying the logical flow of complex digital systems.

199. (D) Magnitude and phase angles
Scalar network analyzers only measure the amplitude of reflected and transmitted signals. In contrast, vector network analyzers measure both the magnitude and the phase angle of these high-frequency signals. This phase information is critical for complete network characterization, impedance matching, and creating highly accurate scattering parameter models.

200. (A) Incident, reflected, and transmitted power waves
Scattering parameters characterize high-frequency electrical networks by measuring how electromagnetic waves propagate through them. Rather than measuring voltages and currents directly, which is difficult at high frequencies, a network analyzer quantifies the behavior of incident, reflected, and transmitted power waves at the ports of the device under test.

201. (B) Direct-writing oscillographic recorder
Direct-writing oscillographic recorders utilize a classic mechanical plotting mechanism to capture electrical variations. An incoming signal drives a galvanometer, which physically rotates an attached writing arm or pen. This pen draws a continuous analog trace directly onto a moving roll of paper, providing an uninterrupted physical record of the signal.

202. (B) Mechanical inertia and friction of pen parts
Mechanical chart recorders are physically limited by the mass and mechanical resistance of their moving components. The pen assembly, galvanometer, and linkage arms possess significant inertia and experience friction against the paper. This physical resistance prevents the pen from responding quickly enough to capture high-frequency transitions, limiting the device to low-frequency signals.

NODIA

203. (A) Sample and Hold output voltage before the ADC converter
A sample and hold circuit captures the value of an analog signal at specific time intervals, making it a discrete-time signal. However, because the held voltage on the capacitor can still take any arbitrary analog value within its range, its

amplitude remains continuous. This state exists prior to quantization by the converter.

204. (C) High-frequency noise and out-of-band interference
Low-pass filters are used in signal conditioning to protect measurement integrity. They allow low-frequency signals of interest to pass through with minimal attenuation while blocking high-frequency noise, electromagnetic interference, and out-of-band signals. This filtering prevents unwanted high-frequency noise from corrupting measurements and causing aliasing during subsequent digitization.

205. (D) Using external acquisition chassis with a central host PC
A standard PC-based data acquisition system typically relies on internal plug-in cards connected directly to the computer bus. In contrast, a hybrid system uses external acquisition chassis that house the digitization modules. These external units communicate with a central host computer over standard networks, combining local processing power with remote modular expansion.

206. (C) Faster switching speeds and longer device lifespan
Solid-state switches, such as field-effect transistors, are preferred over mechanical relays in modern multiplexers. Because they have no moving parts, solid-state switches can transition between channels at high speeds and do not suffer from mechanical wear. This design provides near-infinite operational lifespans and enables rapid multichannel sampling.

207. (B) 2
A differential signal configuration measures the voltage difference between two independent signal lines rather than referencing a single line to ground. Consequently, to route a single differential channel to a measurement instrument, both the positive and negative lines must be switched simultaneously. This setup requires two physical switches per channel.

208. (D) Capacitor charging and input amplifier settling time
Acquisition time represents the delay required for a sample and hold circuit to switch from hold to sample mode and accurately track the input. This duration is physically determined by the time needed to charge the internal storage capacitor and allow the input buffer amplifier to fully stabilize within a specified error band.

209. (A) Extremely low input bias current from FET inputs
The droop rate in a sample and hold circuit represents the unwanted loss of charge from the storage capacitor during the hold phase. To prevent this voltage drift, the output buffer amplifier connected to the capacitor must have high input impedance. Using field-effect transistors ensures extremely low input bias currents, minimizing discharge.

210. (D) 65,536
The number of discrete analog output levels that a digital-to-analog converter can produce is determined by its binary resolution. For a device with sixteen bits, the total number of unique binary combinations is calculated by raising two to the sixteenth power. This mathematical relationship yields exactly sixty-five thousand five hundred thirty-six distinct levels.

211. (A) The analog output consistently increases or remains constant as the digital input code increases
Monotonicity is a critical performance metric for digital-to-analog converters. It guarantees that the output voltage will always change in the same direction as the input code. Specifically, as the digital input code increases, the analog output must consistently increase or remain constant, preventing any negative transitions that could disrupt control loops.

212. (D) 80 kΩ
In a parallel weighted-resistor converter, the resistor values scale exponentially with binary weight. For a four-bit converter, the resistor values are weighted as one, two, four, and eight times the base resistance. If the most significant bit resistor is ten kilohms, the least significant bit resistor must be eight times larger, yielding eighty kilohms.

213. (B) R-2R ladder network
High-resolution converters require precise component matching. A weighted-resistor design for sixteen bits would require an impractically wide range of resistor values. The R-2R ladder network solves this issue by using only two resistor values throughout the circuit. This simplicity

Click Here to Buy book on Amazon

234. (B) Routing the packets to the correct destination IP address
The internet protocol functions at the network layer of the communication stack. Its primary responsibility is to route data packets across interconnected networks from the source device to the destination device. It achieves this by appending addressing information to each packet, ensuring they are directed to the correct destination network address.

235. (A) NRFD (Not Ready For Data)
The three-wire handshake protocol in GPIB networks coordinates data transfers between devices operating at different speeds. The not ready for data line is managed by the listening devices. When this line is released and goes high, it signals to the active transmitter that all connected listeners are ready to accept the next byte.

236. (C) A colon-separated hierarchical text string
Standard Commands for Programmable Instruments defines a standardized language for controlling test equipment. SCPI commands are structured as ASCII text strings organized in a hierarchical, tree-like structure. Colons are used to separate different levels within the command hierarchy, allowing engineers to navigate and control specific instrument sub-systems using readable text.

237. (D) An active backlight unit to illuminate pixels
Liquid crystal molecules do not produce visible light; instead, they act as miniature light shutters that block or transmit light. To form a visible image on the screen, the display assembly must include an active backlight source behind the liquid crystal panel. This backlight provides the uniform illumination necessary to make pixels visible.

238. (C) At least 3 to 5 times the frequency of interest
The analog bandwidth of an oscilloscope represents the frequency at which an input signal is attenuated by three decibels. To accurately capture high-frequency components and fast signal transitions without significant amplitude attenuation, the analog front-end bandwidth should be three to five times higher than the fundamental frequency of the target signal.

239. (B) The resolution bandwidth (RBW) filter
Swept-tuned spectrum analyzers measure frequency components by sweeping a local oscillator across a band. The resulting signal passes through a narrow resolution bandwidth filter. If the sweep speed is too fast, the filter does not have sufficient time to fully respond to amplitude changes, resulting in frequency shifts and amplitude errors.

240. (D) Ultimate sensitivity to detect small signals
The displayed average noise level represents the internal noise floor of a spectrum analyzer under specific settings. This parameter is critical because any signal with an amplitude below this noise floor will be masked and cannot be resolved. Consequently, the DANL serves as the ultimate metric for the instrument's measurement sensitivity.

241. (A) State analysis
Synchronous data capture in a logic analyzer uses an external clock signal supplied by the target system to trigger sampling. This method, known as state analysis, records the digital states precisely when they are stable and valid. It is highly useful for debugging software execution and bus protocols on microprocessors.

NODIA

242. (C) Input reflection coefficient and forward transmission coefficient
Scattering parameters describe the transmission and reflection of electromagnetic waves in high-frequency networks. The parameter $S_{\{11\}}$ represents the input reflection coefficient, which measures the signal reflected back from the input port. The parameter $S_{\{21\}}$ represents the forward transmission coefficient, which measures the signal transmitted from the input port to the output port.

243. (A) Heating a microscopic linear array on thermal paper
Thermal array recorders use a static, high-resolution printhead containing a linear array of microscopic heating elements. As heat-sensitive paper moves past this array, the system selectively heats individual elements to create a dark trace. This electronic printing method eliminates the mechanical lag and wear associated with traditional pen-based recorders.

224. (D) Use isolation components to break electrical conduction paths
Ground loops form when multiple electrical ground paths exist between connected systems, allowing noise currents to circulate. To resolve this, engineers must break the physical galvanic connection between these points. Using isolation components, such as optocouplers, isolation amplifiers, or signal transformers, blocks these circular conduction paths while still allowing signal transmission.

225. (A) Boosting weak signals so they utilize more ADC codes
Low-level signals often span only a fraction of an analog-to-digital converter's input range, resulting in high quantization error. A programmable gain amplifier resolves this by amplifying the weak signal prior to conversion. This ensures the signal spans a larger portion of the converter's input range, utilizing more available digital codes and improving resolution.

226. (B) 305 μV
The size of the least significant bit represents the smallest voltage change the converter can resolve. For a bipolar system spanning negative ten volts to positive ten volts, the total range is twenty volts. Dividing this twenty-volt span by two raised to the sixteenth power yields a step size of approximately three hundred five microvolts.

227. (A) The latency and non-determinism of the computer's operating system
Software triggering relies on the host computer's processor to analyze incoming data and initiate recording. Consequently, this process is constrained by the scheduling delays and non-deterministic behavior of standard operating systems. This processing latency introduces timing uncertainty, making software triggers unsuitable for high-speed applications that require precise, microsecond-level synchronization.

228. (D) The duration a signal remains in a high or low logic state
Pulse width measurement determines the exact duration of a digital pulse. The counter/timer achieves this by gating an internal, high-frequency reference clock. The clock pulses are counted only while the input signal remains in the specified active logic state. Multiplying the counted pulses by the clock period yields the pulse duration.

229. (B) Low power consumption and robust storage
Remote data loggers must operate reliably in the field for extended periods without access to mains power or maintenance. To maximize operational life and prevent data loss, these systems prioritize low electrical power consumption and high-capacity, non-volatile solid-state storage. These features ensure the device can gather and preserve data under harsh conditions.

230. (C) Timing is derived from start/stop bits without a clock line
Asynchronous serial communication transmits data without sharing a common physical clock line between the transmitter and receiver. Instead, the devices agree on a preset communication speed. The receiving device synchronizes its internal timing using start and stop framing bits embedded directly within each transmitted byte, simplifying the physical cabling requirements.

231. (D) Negative voltage is logic 1, positive is logic 0
Standard transistor-transistor logic uses positive voltages for a logical high and zero volts for a logical low. The serial standard, however, uses negative voltage levels to represent a logical one and positive voltage levels to represent a logical zero. This voltage inversion helps improve noise immunity over longer cable lengths.

232. (A) The voltage difference between the A and B lines
Differential signaling transmits data using two balanced conductors, typically designated as the A and B lines. The receiver determines the digital logic state by measuring the voltage difference between these two lines rather than their voltages relative to ground. This approach cancels out common-mode noise, enabling reliable communication over long distances.

233. (B) To hold the bus in a known state when transmitters are idle
When all transmitters on a multi-drop bus are inactive or disconnected, the differential voltage on the lines floats near zero. This undefined state can cause receivers to interpret noise as valid data. Fail-safe biasing resistors apply a small, steady voltage offset to keep the idle bus in a known, stable logical high state.

Downloaded from www.pdf.tube

a logical high state is recognized by receiving equipment. For standard compatible systems, this guaranteed minimum high-level output voltage threshold is set at two point four volts.

174. (C) Data is collected after the trigger event occurs
Post-trigger acquisition is a standard hardware operational mode where data storage begins immediately after a specified trigger condition is met. The system remains idle or ignores inputs until the trigger event occurs, after which it captures a predetermined number of samples. This is useful for recording events that occur following a specific system change.

175. (B) Precision internal reference clock timebase
Frequency measurement requires counting signal transitions over an extremely accurate time interval. A counter/timer chip establishes this precise gating window using its own stable internal reference clock. By counting the number of incoming pulses that occur during this highly controlled period, the system can calculate the frequency of the input signal with high accuracy.

176. (D) The user interface and signal processing are defined in software
Virtual instruments separate the measurement hardware from the user interface and signal processing functions. Because these elements are implemented in software rather than hardwired analog circuitry, engineers can quickly modify acquisition rates, filtering algorithms, and display formats. This software-defined architecture offers unmatched flexibility, allowing rapid system reconfiguration without requiring physical hardware modifications.

177. (A) Sensors are geographically dispersed, reducing analog run lengths
When measurement points are spread across a large physical area, routing long analog cables back to a central processor introduces significant noise and signal degradation. Distributed data loggers resolve this issue by digitizing the signals close to the sensors. The digitized data is then transmitted over robust, noise-immune digital networks to the host system.

178. (C) Solid-state ATA or Linear Flash
Early portable data loggers required durable, non-volatile storage media to retain captured measurements without continuous battery power. PCMCIA cards met this requirement by utilizing solid-state storage technologies like linear flash or solid-state ATA. These robust storage formats allowed data to survive harsh physical conditions and power interruptions during remote field deployments.

NODIA

179. (A) 9600 bits per second
Baud rate measures the number of signal transitions or symbol changes that occur per second along a communication channel. In simple binary serial communications, such as standard serial configurations, each symbol represents exactly one bit of data. Therefore, a signaling speed of ninety-six hundred baud directly translates to a transfer rate of ninety-six hundred bits per second.

180. (A) DTE
Serial communication standards classify connected devices into specific roles to establish proper wiring and pin assignments. Standard personal computers act as primary data sources or destinations, designating them as data terminal equipment. This classification determines the direction of control and data signals on the physical connector when interfacing with peripheral communication devices.

181. (A) Two DTE devices directly together
Standard serial connections are designed to connect data terminal equipment to data circuit-terminating devices. If two terminal devices are connected directly, their transmit and receive pins will conflict. A null-modem cable resolves this by crossing the transmit and receive lines, allowing the two terminal devices to communicate directly without a modem.

182. (B) 120 ohms
High-speed digital signals traveling down long cables can bounce back when they reach the end of the line, causing data corruption. To prevent these reflections, the network must be terminated with a resistance that matches the characteristic impedance of the twisted-pair cable. For standard cables, this nominal termination value is typically one hundred twenty ohms.

183. (D) Signal reflections will occur, causing data corruption
Omitting termination resistors on long communication lines causes an impedance mismatch at the cable ends. When high-speed

244. (D) Dynamic range and minimum detectable signals
The bit resolution of an analog-to-digital converter determines the number of discrete steps used to represent the input voltage range. Increasing the number of bits reduces the size of each step, which lowers the quantization noise floor. This improvement directly expands the system's dynamic range, enabling the detection of much smaller signals.

245. (B) It uses oversampling, noise shaping, and low-pass filtering
Sigma-delta digital-to-analog converters use high oversampling rates to distribute quantization noise over a wider bandwidth. A feedback modulator then performs noise shaping to shift the bulk of this noise out of the signal band into higher frequencies. Finally, a low-pass filter removes the high-frequency noise, producing a high-resolution analog output.

246. (C) Transfer data to PC memory without heavily loading the CPU
High-speed data acquisition systems generate large volumes of digital samples that must be transferred to system memory quickly. Direct memory access allows the acquisition hardware to write these samples directly into the computer's RAM. This bypasses the main processor, preventing CPU bottlenecks and ensuring stable data transfers without dropped samples.

247. (D) Enter and remain within a defined error band after a step
Settling time is a critical dynamic specification for operational amplifiers subjected to rapid input changes. It measures the total time elapsed from the application of an input step until the output voltage enters and remains within a specified error band around its final value, ensuring the signal is stable before digitization.

248. (A) Higher frequencies due to parasitic capacitive coupling
Crosstalk is the unwanted transfer of signal energy between adjacent multiplexer channels. This parasitic leakage is primarily driven by small capacitive coupling paths that exist between adjacent switches and trace lines on the circuit board. Because the impedance of a capacitor decreases as frequency increases, crosstalk becomes more severe at higher signal frequencies.

249. (B) Lower power consumption and better matching in CMOS designs
Charge-redistribution successive approximation converters use an array of switched capacitors rather than a resistor ladder to perform conversions. This capacitor array can be fabricated with high precision and matching using standard CMOS processes. Additionally, since capacitors do not draw continuous direct current, this architecture offers significantly lower power consumption than resistor-based designs.

250. (B) Lower frequency artifacts in the digitized data
Aliasing occurs when an analog signal is sampled at a rate below the Nyquist limit. When this happens, high-frequency components that exceed half the sampling frequency fold back into the primary frequency band. This folding causes these high-frequency signals to appear as lower-frequency artifacts that cannot be distinguished from true low-frequency signals.

251. (B) ~2.44 mV
To find the voltage error corresponding to one least significant bit, the full-scale range is divided by the total number of quantization steps. For a twelve-bit converter, the total number of steps is four thousand ninety-six. Dividing ten volts by this value yields a step size of approximately two point forty-four millivolts.

252. (C) Trades conversion latency for high throughput at high resolution
Flash converters digitize inputs instantly using a massive parallel array of comparators, which limits them to lower resolutions. Pipeline converters pass the signal through several sequential stages, with each stage resolving a few bits. This pipelined architecture introduces a slight latency but allows high throughput at much higher resolutions using far fewer comparators.

253. (D) Johnson-Nyquist thermal noise
Thermal noise, also known as Johnson-Nyquist noise, is generated by the random thermal agitation of charge carriers inside any electrical conductor at temperatures above absolute zero. Because this noise is an inherent physical property of resistance, it cannot be eliminated by shielding or circuit design, making it fundamentally unavoidable in any resistive circuit.

Click Here to Buy book on Flipkart

(B) Twice the highest frequency component in the signal
(C) The bit resolution of the integrated Digital-to-Analog Converter
(D) The physical size of the temporary memory buffer on the DAQ device

2001
18. What is a defining characteristic of a Real-Time Operating System (RTOS) used in embedded virtual instrumentation?
(A) It guarantees an absolutely unbounded execution time for all tasks
(B) It prioritizes graphical user interface rendering over background tasks
(C) It requires constant internet connectivity to function
(D) It provides deterministic task execution with bounded maximum response times

2006
19. What does the term SCADA stand for in industrial automation?
(A) Supervisory Control and Data Acquisition
(B) Sequential Computing and Dynamic Allocation
(C) Synchronous Communication and Digital Analysis
(D) System Calibration and Device Automation

2014
20. Match the advanced network connectivity features with their correct descriptions.
List I: (Feature)
P. Web Server
Q. Remote Panels
R. Network Shared Variables
S. SMTP VIs
List II: (Description)
1. Programmatically sends emails
2. Exchanges data between distributed applications
3. Hosts HTML representations of the instrument
4. Allows full client control of a VI's front panel
(A) P-3, Q-4, R-2, S-1
(B) P-4, Q-3, R-1, S-2
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-2, R-3, S-4

2009
21. Which technology enables a Virtual Instrument to programmatically open Microsoft Excel and populate it with data?
(A) ActiveX / Component Object Model (COM)
(B) OLE for Process Control (OPC)
(C) Transmission Control Protocol (TCP)
(D) Interchangeable Virtual Instruments (IVI)

2025
22. In a PID control simulation, which component is primarily responsible for eliminating steady-state error?
(A) The Proportional term
(B) The Derivative term
(C) The Feedforward gain
(D) The Integral term

2013
23. What is the standard purpose of edge detection algorithms in machine vision processing?
(A) To compress the raw high-resolution image file size for quick web transmission
(B) To identify contrasting boundaries for measurement and inspection
(C) To convert a single grayscale image into a simulated full RGB color spectrum
(D) To increase the overall ambient brightness level of the incoming camera feed

2010
24. When configuring automated motion control, what is a motion trajectory?
(A) The electrical current profile consumed directly by the driver
(B) The digital logic sequence used to initialize the physical encoder
(C) The calculated path of positions, speeds, and timing
(D) The physical wiring route used between the controller and the motor

NODIA

2005
25. Which statement accurately describes the evolution of measurement systems toward Virtual Instrumentation?
(A) The system design evolved to rely exclusively on unmodifiable hardware analog circuits
(B) The developmental trend involved removing personal computers from the measurement loop
(C) The rapid growth of virtual instrumentation rendered all physical sensors obsolete
(D) The shift from hardware-centric boxes to software-defined architectures

2018
26. Which of the following is NOT considered a core component of a computer-based measurement system?
(A) A mechanical pneumatic pump

reflected back from the input port. A vector network analyzer is uniquely suited for this task because it measures both the magnitude and phase of reflected waves. This capability allows it to calculate return loss and voltage standing wave ratios.

265. (B) Converting time domain samples into a frequency spectrum
To provide a spectral display, a digital storage oscilloscope must transform sampled input data. The instrument captures continuous voltage variations over time and applies a fast Fourier transform algorithm to these samples. This mathematical conversion extracts the frequency components, shifting the representation from the time domain to the frequency spectrum.

266. (B) Capacitor leakage currents and buffer input bias currents
In an ideal sample and hold circuit, the held voltage should remain perfectly constant during the hold phase. In physical circuits, however, the stored charge gradually leaks away, causing a voltage droop. This decay is primarily driven by the internal leakage current of the storage capacitor and the input bias current of the buffer amplifier.

267. (A) The required multiplexer settling and Sample and Hold acquisition times
In a multiplexed data acquisition system, the system must switch between different channels before each conversion. Each transition requires a finite delay to allow the multiplexer's output to settle and the sample and hold circuit to acquire the new signal. These necessary settling delays reduce the overall throughput rate below the converter's raw speed.

268. (C) It needs only two resistor values (R and 2R), easing fabrication
Fabrication of high-resolution digital-to-analog converters requires highly matched components. A twelve-bit weighted-resistor design would require an impractically wide range of precise resistance values, which is extremely difficult to manufacture on silicon. The R-2R ladder simplifies fabrication by using only two resistor values, ensuring easier matching and better thermal tracking.

NODIA

269. (D) An additive, uniformly distributed white noise source
Quantization error arises from the rounding process that occurs when mapping continuous analog voltages to discrete digital levels. For complex, busy signals, this error varies randomly from sample to sample. Consequently, it behaves mathematically as an additive, uniformly distributed white noise source, spreading its energy evenly across the Nyquist bandwidth.

270. (C) IEEE 488 (GPIB) interface bus
GPIB was the dominant interface for connecting laboratory instruments for several decades. In modern data acquisition architectures, the LAN eXtensions for Instrumentation standard has largely replaced this older parallel bus. LXI uses standard TCP/IP networks to transmit SCPI commands, offering higher speeds, longer cable runs, and lower integration costs.

****

CHAPTER 05
Virtual Instrumentation

2003

1. What is the primary advantage of Virtual Instrumentation over traditional hardware-based instrumentation?
(A) Elimination of physical sensors in the measurement loop
(B) Flexibility to define instrument functions through user-defined software
(C) Higher power consumption enabling stronger signal generation
(D) Reliance on proprietary, manufacturer-defined hardware controls

2004

2. In a virtual instrumentation system architecture, which component bridges the physical sensors and the computer?
(A) The Application Software
(B) The Graphical User Interface
(C) The Network Interface Card
(D) The Data Acquisition Hardware

2001

3. Which of the following is NOT a characteristic of the data-flow programming paradigm?
(A) Execution is strictly sequential line-by-line
(B) A node executes only when all required inputs are present
(C) Data paths are defined by wires connecting nodes
(D) Independent parallel paths can execute simultaneously

2022

4. In a Virtual Instrument environment, what is the primary function of the front panel?
(A) To construct and edit the graphical source code of the block diagram
(B) To directly configure physical hardware sampling parameters and limits
(C) To provide the primary user interface with controls and indicators
(D) To store and log acquired data files directly onto the hard drive

2002

5. When designing a hierarchical Virtual Instrument, what occurs when a Sub-VI is integrated into a main VI?
(A) The Sub-VI acts as a modular function call within the block diagram
(B) The Sub-VI operates completely independently of the main program flow
(C) The main VI code is automatically overwritten by the Sub-VI
(D) The connector pane is deleted to save memory

2001

6. Which structure is most appropriate when a block of code must execute an unknown number of times until a specific condition is met?
(A) For Loop
(B) Flat Sequence Structure
(C) MathScript Node
(D) While Loop

2016

7. Compared to a Flat Sequence structure, what is the primary structural difference of a Stacked Sequence structure?
(A) It executes frames simultaneously rather than sequentially
(B) It visually overlaps frames to conserve block diagram space
(C) It utilizes global variables instead of local variables
(D) It requires external hardware triggers to proceed between frames

2025

8. Based on the concept of complex data types, how does a Cluster differ from an Array in graphical programming?
(A) A Cluster groups elements of the same data type, while an Array groups mixed types
(B) A Cluster groups Boolean data values, whereas an Array groups numeric values
(C) A Cluster groups mixed data types, while an Array groups elements of the same type
(D) A Cluster has a fixed number of elements, whereas an Array is strictly single-

Downloaded from www.pdf.tube

dimensional

2017

9. Which data visualization tool is best suited for displaying continuously acquired single-point data by appending it to a historical buffer?
(A) Waveform Graph
(B) XY Graph
(C) Intensity Graph
(D) Waveform Chart

2015

10. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Formula nodes in virtual instrumentation are used to execute complex mathematical equations using text-based syntax.
Reason (R): They contain a text-based parser that interprets equations, eliminating the need for multiple graphical arithmetic nodes to reduce block diagram clutter.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

11. Which pair correctly identifies a memory management variable and its appropriate scope?
(A) Local Variable - Transfers data between different computers over a network
(B) Shared Variable - Transfers data across the network or between separate VIs
(C) Global Variable - Transfers data within a single loop
(D) Control Reference - Stores permanent data on the hard drive

2017

12. Which of the following INCORRECTLY pairs a file I/O format with its characteristic?
(A) Text File - Human readable but consumes more storage space
(B) TDMS File - Unstructured flat file format without built-in metadata support
(C) Binary File - Highly efficient storage but not easily readable in a text editor
(D) Spreadsheet File - Tab-delimited text designed for easy import to Excel

2012

13. Which feature represents the most significant advantage of the TDMS data storage format over standard binary files?
(A) It includes self-describing metadata alongside raw data streams
(B) It relies entirely on standard ASCII characters for all data representation
(C) It restricts the system to single-channel high-speed data acquisition
(D) It automatically encrypts all numerical values by default for security

NODIA

2011

14. Which statement about the RS-485 serial interface is correct?
(A) It supports point-to-point communication channels between two devices
(B) It exhibits high susceptibility to electromagnetic noise over extremely long distances
(C) It uses differential signaling to enable multi-drop networking
(D) It relies on a 4-20mA current loop for analog transmission

2017

15. The SCPI standard used in IEEE 488 (GPIB) instrumentation is best described as what?
(A) A physical hardware pinout specification designed for legacy parallel cables
(B) A high-speed digital-to-analog conversion algorithm used in signal processing
(C) A real-time operating system dedicated solely to embedded virtual controllers
(D) A standard text-based command language for programmable instruments

2015

16. In standardized instrumentation software, what is the primary role of VISA?
(A) To generate and run complex mathematical models and simulations automatically
(B) To act as a compiler for converting high-level graphical code directly into C++
(C) To provide a high-level API that abstracts hardware communication
(D) To regulate and monitor the physical electrical voltage levels on the GPIB bus

2025

17. Which parameter dictates the minimum sampling rate required to accurately digitize an analog signal without aliasing?
(A) The overall voltage amplitude and absolute power of the analog signal

2009

56. What operation must typically be performed before mathematical functions can be applied to individual elements within a Cluster?
(A) Save the cluster into a binary file
(B) Bundle the elements of the cluster
(C) Unbundle elements from the cluster
(D) Cast the entire cluster into a string

2004

57. Which characteristic is least relevant to a Waveform Chart?
(A) It maintains a continuous history of previously acquired data points
(B) It is ideal for displaying slow, continuous temperature logs
(C) It processes incoming scalar input variables on a point-by-point basis
(D) It plots blocks of data at once, erasing past traces

2024

58. How does a developer integrate a proprietary C-based algorithm directly into a graphical Virtual Instrument without rewriting it?
(A) By using a Call Library Function Node to link a DLL
(B) By directly typing raw C source code statements into a string control
(C) By translating and compiling the C code directly into an HTML document
(D) By mapping execution steps to standard numeric mathematical node blocks

2017

59. What is a significant disadvantage of relying entirely on Global Variables to pass data between multiple concurrent loops?
(A) They consume less memory than local variables
(B) They can lead to race conditions due to a lack of synchronization
(C) They prevent the loops from executing at the same time
(D) They automatically write data to the hard drive, slowing the system

2016

60. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Reading large amounts of data in binary format is generally much faster than reading it in text format.
Reason (R): Binary files store data in the machine's native memory representation, eliminating the need for ASCII conversion parsing.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2024

61. Which advanced technique allows a Virtual Instrument to query a SQL server for historical data?
(A) Database Connectivity Toolkits
(B) Direct Memory Access (DMA) channels
(C) Multi-iteration Shift Registers
(D) Auto-indexed data array structures

2006

62. Which of the following INCORRECTLY pairs the serial protocol with its characteristic?
(A) RS-232C - Short distance, point-to-point communication systems
(B) RS-485 - Multi-drop, long distance differential signaling networks
(C) RS-232C - Resistant to ground potentials over long runs
(D) RS-422 - Multi-drop, high-speed unidirectional communications

2010

63. What role does an Instrument Driver play in parallel interfacing?
(A) It powers and distributes electrical energy directly to the hardware
(B) It operates as a mechanical routing relay to physically switch signals
(C) It standardizes the physical and mechanical shape of the GPIB port
(D) It provides software functions that abstract raw SCPI commands

2012

64. What does the acronym IVI stand for in standardized instrumentation?
(A) Integrated Voltage Indicator
(B) Interleaved Variable Integration
(C) Interchangeable Virtual Instruments
(D) Internal Vector Interface

2023

65. If a DAQ module has a 12-bit ADC configured for a voltage range of 0 to 10 V, what is the approximate resolution of the system?
(A) 1.22 mV
(B) 2.44 mV

Click Here to Buy book on Amazon

(B) Transducers and sensors
(C) Signal conditioning circuitry
(D) Data acquisition interface

2023

27. How does a node in a graphical data-flow program behave compared to a traditional sequential code statement?
(A) It waits for a specific clock cycle regardless of input availability
(B) It executes when data arrives at all of its required input terminals
(C) It executes based on its physical placement from top to bottom
(D) It interrupts all other operations globally upon execution

2007

28. Which of the following would be an INCORRECT use of a front panel control?
(A) To allow the user to input a numeric threshold
(B) To display a dynamically updating temperature graph
(C) To toggle a Boolean switch indicating system state
(D) To select an item from a drop-down menu

2008

29. By editing the icon of a Sub-VI, a programmer primarily achieves what?
(A) Visual identification of the VI's purpose on a block diagram
(B) Increased execution speed of all active background mathematical routines
(C) Reduced memory consumption of the compiled virtual instrument software
(D) Automatic generation of standardized online HTML code documentation

2009

30. Consider the following statements regarding iterative control structures:
I. A While loop always executes at least once before checking the terminal condition.
II. A For loop cannot execute zero times under any circumstances.
III. Shift registers transfer data from one iteration of a loop to the next.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I only

2011

31. Which structure functions most similarly to an "if-then-else" statement in text-based programming?
(A) Sequence Structure
(B) For Loop
(C) Event Structure
(D) Case Structure

2022

32. In the context of complex data types, what is the primary purpose of an Error Cluster?
(A) To generate random error codes during high-stress unit testing
(B) To terminate the execution safely when safe operating limits are exceeded
(C) To group a Boolean status, a numeric code, and a text source
(D) To store standard numeric datasets for multi-variable math calculations

2007

33. When displaying data in a Virtual Instrument, why would a developer choose an XY Graph over a Waveform Graph?
(A) Because XY Graphs automatically filter out high-frequency sensor noise
(B) Because the data points are sampled at irregular time intervals
(C) Because Waveform Graphs cannot process and display multi-channel plots
(D) Because XY Graphs consume zero operational system RAM during execution

NODIA

2008

34. What is the distinct advantage of using a MathScript node in a graphical program?
(A) It automatically converts and packages the entire program into an executable file
(B) It provides low-level direct access to raw physical memory addresses on the PC
(C) It completely bypasses and replaces the need for external data acquisition devices
(D) It executes text-based mathematical scripts alongside graphical code

2009

35. Which issue is most likely to occur if local variables are used excessively and indiscriminately in a concurrent graphical program?
(A) Race conditions and unpredictable data overwriting may occur
(B) The program will automatically switch to sequential execution
(C) The variables will convert themselves into global variables

254. (C) They cancel common-mode noise picked up along the lines
Long signal cables running from remote sensors are highly vulnerable to electromagnetic interference. Single-ended configurations measure signals relative to a shared ground, which can introduce ground loops and noise. Differential inputs measure the voltage difference between two dedicated lines, allowing the system to cancel out common-mode noise that affects both wires equally.

255. (B) Block Diagram
In software-based data acquisition platforms, a virtual instrument is divided into two main components. The front panel serves as the user interface, containing graphical controls and indicators. The block diagram contains the graphical source code, defining the signal flow, mathematical operations, and hardware control paths that govern the instrument's behavior.

256. (D) RS-232C
The serial communication standard commonly utilized a nine-pin D-subminiature connector on older personal computers. This connector, often designated as the DB-9 port, routed the essential transmit, receive, ground, and handshake control lines needed to establish asynchronous serial connections with external devices like modems, printers, and early data acquisition modules.

257. (A) Daisy-chain (bus) topology
RS-485 networks are designed for multi-point communication over long distances. To minimize signal reflections and maintain proper impedance matching along the transmission line, devices must be connected in a continuous daisy-chain or bus topology. Avoiding star configurations prevents stub reflections, ensuring reliable high-speed data transmission across all connected network nodes.

258. (C) Standard data formats, status reporting, and common commands
The original GPIB standard focused primarily on the physical and electrical specifications of the interface bus. The subsequent dot-two revision built upon this foundation by standardizing how instruments interpret data. It defined common commands, data formats, and status-reporting structures, ensuring greater compatibility and ease of programming across different manufacturers' instruments.

259. (A) The active liquid crystal layer
Liquid crystal displays control light transmission by manipulating the polarization angle of light passing through the panel. The active liquid crystal layer contains molecules that physically realign when an electrical voltage is applied. This realignment changes the optical properties of the layer, allowing it to control the rotation of light polarization.

260. (D) The bit resolution of its internal ADC converter
The vertical resolution of a digital storage oscilloscope determines its ability to resolve small voltage changes in the input signal. This parameter is directly defined by the bit resolution of the internal analog-to-digital converter. A higher number of bits divides the vertical range into more steps, providing finer amplitude detail.

261. (B) The mixer to generate spurious intermodulation distortion
Applying an excessively strong input signal to a spectrum analyzer drives its internal front-end components, particularly the mixer, into non-linear operation. This saturation causes the mixer to generate spurious intermodulation distortion products that appear as non-existent spectral peaks on the display, compromising the accuracy of the frequency analysis.

262. (C) Logic Analyzer
Verifying the operation of a parallel digital bus requires monitoring multiple digital lines simultaneously to analyze complex timing relationships and state transitions. While oscilloscopes are limited by channel count, a logic analyzer provides dozens of channels to capture and display synchronized digital states, making it essential for digital bus verification.

263. (D) Periodic and highly repetitive
Equivalent-time sampling reconstructs high-frequency waveforms by capturing individual samples across multiple occurrences of the signal. Because this technique relies on collecting data points over time to compile a complete picture, the input waveform must be highly stable, periodic, and repetitive. It cannot capture non-repeating, single-shot transient events.

264. (A) Vector Network Analyzer
Characterizing antenna performance requires measuring how much high-frequency energy is

Downloaded from www.pdf.tube

synchronization through digital I/O pins
(D) Generating continuous random datasets to simulate high-frequency noise

2001

46. If a simulated system exhibits a highly oscillating response to a step input, which PID parameter adjustment is typically most appropriate to dampen the oscillations?
(A) Increasing Proportional gain
(B) Decreasing Integral time
(C) Increasing Derivative time
(D) Setting all parameters to zero

2001

47. In automated machine vision, what is the process of converting a grayscale image into a black-and-white image based on a specific pixel intensity value called?
(A) Blurring
(B) Interpolation
(C) Rasterizing
(D) Thresholding

2023

48. Which component is used to provide feedback on the actual physical position of a motor in a closed-loop motion control system?
(A) A variable frequency drive
(B) A solid-state relay
(C) An optical encoder or resolver
(D) A power supply unit

2008

49. Which of the following represents a key characteristic that distinguishes Virtual Instrumentation from standard programming?
(A) It is deployed exclusively for relational database administration and management
(B) It integrates hardware, data analysis, and a graphical interface
(C) It completely avoids all modern object-oriented programming methodologies
(D) It lacks any basic capability to execute standard text string operations

2023

50. Consider the following statements regarding Virtual Instrument architecture:
I. The PC acts as the central processor for data analysis and display.
II. Signal conditioning converts dangerous voltages to safe levels for the DAQ.
III. DAQ modules translate digital data back into physical phenomena for sensors.
IV. Software platforms integrate both hardware control and data visualization.
V. Virtual instruments are incapable of generating output signals.
Which of the above statements are correct?
(A) I, II, III and IV
(B) I, II and IV
(C) II, IV and V
(D) I, III, IV and V

NODIA

2011

51. What dictates the flow of execution in a Virtual Instrumentation block diagram?
(A) The flow of data through the connecting wires
(B) The physical numbering of the nodes
(C) The chronological order in which the nodes were placed on the screen
(D) The alphabetical order of the function names

2001

52. Which element on a tool palette is specifically used to create data paths between nodes on a block diagram?
(A) Operating tool
(B) Positioning tool
(C) Wiring tool
(D) Labeling tool

2006

53. The connector pane of a VI is functionally analogous to what in text-based programming?
(A) A function's parameter list
(B) The main program execution function
(C) A globally scoped data variable
(D) An inline source code comment

2023

54. What feature allows a For Loop to dynamically set its iteration count based on the size of an incoming array?
(A) Shift Register
(B) Feedback Node
(C) Conditional Terminal
(D) Auto-Indexing

2025

55. Which control structure is specifically designed to handle asynchronous user interactions, such as clicking a button?
(A) While Loop
(B) Event Structure
(C) Sequence Structure
(D) Formula Node

(D) The compiler will refuse to save the VI

2019
36. Which function is fundamental for parsing structured textual data read from a basic text file?
(A) Image pattern matching routines
(B) Analog-to-Digital data conversion
(C) String manipulation functions
(D) Closed-loop PID control tuning

2003
37. What role do configuration (INI) files typically serve in virtual instrumentation?
(A) They store human-readable parameters to initialize the application
(B) They store large, high-speed binary waveform streams and data
(C) They contain compiled machine-level executable code for embedded targets
(D) They encrypt high-speed network communications between secure servers

2018
38. Why is a 4-20mA current loop preferred over standard voltage signals for long-distance industrial instrumentation?
(A) It transmits data at gigabit speeds
(B) It requires no physical wiring between transmitter and receiver
(C) It inherently provides a graphical interface
(D) It is highly immune to voltage drops and electrical noise

2011
39. Which hardware architecture defines a robust 8-bit parallel multi-master bus widely used for connecting laboratory instruments?
(A) RS-232
(B) IEEE 488 (GPIB)
(C) Universal Serial Bus (USB)
(D) OLE for Process Control

2011
40. Consider the following statements regarding VISA:
I. VISA provides a common interface for serial, GPIB, and USB instruments.
II. VISA commands are strictly dependent on the specific hardware manufacturer.
III. VISA significantly reduces instrument code portability.
IV. VISA handles all low-level driver calls seamlessly.
Which of the above statements are INCORRECT?
(A) I and II
(B) II and III
(C) I, II and IV
(D) I and IV

2025
41. In Data Acquisition, what determines the smallest change in analog voltage that an ADC can detect?
(A) The sample rate
(B) The input impedance
(C) The trigger type
(D) The resolution of the ADC

2003
42. How does an Embedded Controller differ from a standard desktop PC in a virtual instrumentation context?
(A) It is ruggedized and runs a deterministic OS for standalone use
(B) It runs graphical execution environments exclusively on a remote cloud server
(C) It lacks any onboard microprocessing units, physical memory, or local RAM
(D) It only supports low-speed single-channel analog inputs and indicators

2012
43. In industrial automation, OPC (OLE for Process Control) is utilized primarily for what purpose?
(A) To fully replace standard hardware PID control loops with artificial intelligence algorithms
(B) To act as a communication bridge between varying automation systems
(C) To automatically design front panel graphical visual indicators and displays
(D) To write raw data directly to register memory, bypassing the operating system

2013
44. Which tool allows a developer to programmatically send a status report or alert from a Virtual Instrument across the internet?
(A) MathScript Node
(B) SMTP VIs
(C) RS-485 Serial
(D) Case Structure

2007
45. What is the fundamental mechanism behind ActiveX communication in a Virtual Instrument?
(A) Using COM technology to share data with external applications
(B) Passing digital and analog information via standard system audio cables
(C) Executing direct hardware timing

Click Here to Buy book on Flipkart

(C) 4.88 mV
(D) 10.0 mV

2006

66. Why is a standard desktop operating system like Windows generally unsuitable for strict Real-Time Embedded systems?
(A) Windows does not support graphical interfaces
(B) Windows lacks the high-level network protocols required
(C) Windows is entirely incompatible with C++ code
(D) Windows task scheduling is non-deterministic, risking missed deadlines

2011

67. Which feature is most central to the design of an HMI (Human Machine Interface) in Industrial Automation?
(A) Process graphics and operator controls
(B) Clock speed optimization of the processor
(C) Modifying the core operating system kernel
(D) High-speed Fourier transform calculations

2021

68. Which method is most effective for continuously viewing a Virtual Instrument's front panel from a remote location using a web browser?
(A) Saving the panel as a JPEG every hour
(B) Emailing a TDMS file to the remote user
(C) Configuring the VI Web Server to publish a Remote Panel

2021

69. Automated report generation via VI typically involves interfacing with word processors. This is commonly achieved using which inter-application protocol?
(A) ActiveX / COM
(B) SCPI
(C) GPIB
(D) UDP

2007

70. Match the PID control terms with their corresponding definitions.
List I: (Term)
P. Proportional
Q. Integral
R. Derivative
S. Setpoint
List II: (Definition)
1. Predicts future errors based on the rate of change
2. The desired target value for the system
3. Reacts to the current magnitude of the error
4. Accumulates past errors over time
(A) P-3, Q-4, R-1, S-2
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-2, S-1

2014

71. In the context of IMAQ, what is hardware interfacing for machine vision primarily concerned with?
(A) Compiling and building raw executable source code
(B) Transferring image pixel data directly to PC memory
(C) Calculating mechanical kinematic paths for robotic arms
(D) Adjusting decibel output levels for auditory alarms

2005

72. Which parameter is NOT inherently configured during axis configuration in automated motion control?
(A) Encoder resolution
(B) Gear ratios
(C) Network IP address of the HMI
(D) Hardware limits and home position

2010

73. Which of the following constitutes the most significant evolutionary step of modern Virtual Instrumentation over classic benchtop instruments?
(A) Replacing analog CRT screens with digital LCD screen displays
(B) Upgrading standard power supplies from 110V to 220V configurations
(C) Standardizing purely mechanical connection switches on front panels
(D) Separation of measurement hardware from the software

2021

74. Which DAQ hardware component is necessary to modify a sensor's raw, noisy, microvolt-level signal into a clean, 0-5V signal suitable for digitization?
(A) The Signal Conditioning module
(B) The Analog-to-Digital Converter
(C) The USB cable
(D) The Application Software

Downloaded from www.pdf.tube

Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2013
131. When integrating external C/C++ code into a VI via a dynamic link library (DLL), which advanced node is specifically designed for this purpose?
(A) Call Library Function Node
(B) MathScript Node
(C) Formula Node
(D) Feedback Node

2004
132. What is the fundamental danger of using Local Variables to write to the same front panel indicator from two parallel loops simultaneously?
(A) The local system RAM memory resources will completely overflow
(B) The compiler throws a syntax error and halts system execution
(C) Race conditions occur, making the output value unpredictable
(D) The target indicator changes its compiled data type dynamically

2022
133. Which technique is most appropriate for searching a large, purely textual string for a specific numeric value?
(A) Using Match Regular Expression functions
(B) Applying a standard low-pass digital filter
(C) Converting the string into a boolean array
(D) Routing the raw string to a Formula Node

2005
134. Which statement correctly identifies a limitation of INI configuration files?
(A) They are completely unable to store standard Boolean data values
(B) They are only compatible with Unix and Linux operating systems
(C) They require dedicated database management systems to edit and open
(D) They are inefficient for high-speed continuous waveform data

2012
135. What is the primary function of the baud rate parameter in RS-232 communication?
(A) It sets the maximum voltage level of the transmission
(B) It establishes the speed of data transmission in bits per second
(C) It defines the physical length of the cable allowed
(D) It dictates the number of devices allowed on the network

NODIA

2017
136. Which characteristic makes the IEEE 488 (GPIB) standard robust for laboratory environments?
(A) It uses shielded cables, secure stackable connectors, and hardware handshaking
(B) It relies on low-power wireless transmission protocols over unlicensed frequencies
(C) It transmits high-bandwidth data signals exclusively through optical fiber lines
(D) It operates on a legacy analog transmission system using frequency multiplexing

2019
137. Which software layer allows a single virtual instrument application to control a Keithley multimeter via USB or an Agilent multimeter via GPIB with minimal code changes?
(A) Real-time operating systems designed for embedded hardware controllers
(B) Interchangeable Virtual Instruments (IVI) driver architectures
(C) Supervisory Control and Data Acquisition (SCADA) system software
(D) Technical Data Management Streaming (TDMS) file-access APIs

2018
138. In a data acquisition system, what effect does increasing the amplification gain of the signal conditioning stage have?
(A) It reduces the input impedance of the buffer, thereby decreasing the effective resolution of the converter
(B) It scales small input signals to span a larger portion of the ADC range, enhancing measurement precision
(C) It introduces phase delays in the conditioning stage, which directly limits the maximum sampling rate
(D) It initiates the conversion process that transforms the analog voltage into a discrete digital representation

2017
139. What is a key requirement for compiling a VI to run on an Embedded Controller?
(A) The VI must target the specific RTOS and hardware architecture of the controller
(B) The host computer must be fully disconnected

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

(B) Write → Open → Close
(C) Open → Write → Close
(D) Read → Format → Write → Display

2008

85. What specific metadata structure makes TDMS files self-describing?
(A) An integrated hierarchy of files, groups, and channels
(B) A separate, external PDF reference document linked directly to the file
(C) A standardized HTML file header embedded directly at the top of text
(D) A highly dedicated SCPI command dictionary compiled inside the binary

2008

86. Which serial interface standard is mathematically balanced (differential) to reject common-mode noise?
(A) RS-232
(B) GPIB
(C) Standard USB
(D) RS-485

2011

87. In IEEE 488 (GPIB) architecture, an instrument that can send data to the bus but cannot be directed to receive commands is classified as a:
(A) Controller
(B) Talker-only
(C) Listener-only
(D) Master

2018

88. What is the fundamental concept behind Interchangeable Virtual Instruments (IVI)?
(A) Replacing functional test software blocks with physical hardware instruments
(B) Automatically converting parallel buses to high-speed serial interfaces
(C) Swapping hardware from different vendors without altering test software
(D) Designing and developing custom silicon microchips for every measurement

2022

89. Which data acquisition term describes the process of synchronizing the start of a measurement with an external electrical pulse?
(A) Sampling
(B) Multiplexing
(C) Filtering
(D) Triggering

2006

90. Consider the following statements regarding Real-Time Operating Systems (RTOS):
I. RTOS prioritize task determinism over overall throughput.
II. RTOS are immune to hardware failures.
III. RTOS ensure critical tasks execute within strict, defined time limits.
IV. RTOS are typically identical to standard desktop operating systems.
Which of the above statements are correct?
(A) I and III
(B) II and IV
(C) I, II and III
(D) I, III and IV

2019

91. In an OPC (OLE for Process Control) architecture, what is the role of an OPC Server?
(A) To display high-level graphical trend charts directly to the plant manager
(B) To translate proprietary hardware protocols to standard client formats
(C) To record and archive digital video surveillance feeds from factory cameras
(D) To physically manage and switch the power supplies of heavy industrial motors

2016

92. What is the most significant limitation of utilizing standard email (SMTP VIs) for critical real-time industrial alarms?
(A) Programmed email messages are fundamentally incapable of transmitting numeric data
(B) SMTP delivery times are non-deterministic and subject to network delays
(C) SMTP protocols require specialized and dedicated analog DAQ hardware modules
(D) Emails are restricted to plain text and cannot be generated programmatically

2004

93. When an application generates an automated Microsoft Word report via ActiveX, what is the Virtual Instrument acting as?
(A) An ActiveX Client
(B) An ActiveX Server
(C) A COM Registry
(D) A standard TCP Node

2009

94. In system simulation, what is the primary effect of an excessively high Proportional gain in a PID controller?
(A) The system becomes entirely unresponsive

Click Here to Buy book on Amazon

2014

75. What happens in a data-flow diagram if a node requires three inputs, but only two have received data?
(A) The node executes using default values for the missing input
(B) The node will not execute until the third input receives its data
(C) The node pauses the entire system indefinitely without warning
(D) The node skips execution and passes an error cluster downstream

2016

76. Which of the following front panel elements is classified as an indicator?
(A) A toggle switch
(B) An LED bulb
(C) A numeric entry box
(D) A slider knob

2022

77. What is the fundamental requirement for allowing data to flow from a main VI into a Sub-VI?
(A) The Sub-VI's connector pane terminals must be wired
(B) The Sub-VI must reside in the exact same local folder directory
(C) The Sub-VI block diagram must run a continuous active While loop
(D) The Sub-VI graphic representation must use a completely blank icon

2024

78. Which statement about a Feedback Node is correct?
(A) It behaves exactly like a local variable and causes race conditions
(B) It serves strictly to reverse the counting direction of For loops
(C) It stores data from a previous loop run for the next iteration
(D) It transmits real-time variables directly to external web servers

2004

79. When an Event Structure is placed inside a While Loop, what is the typical result of configuring a "Timeout" event?
(A) The execution thread terminates immediately when the timer is reached
(B) The operating system triggers a shutdown to prevent system overheating
(C) All front panel inputs and controls are locked and permanently disabled
(D) The loop executes a frame if no user interaction occurs in time

2005

80. Consider the following statements regarding Complex Data Types:
I. Arrays can be multi-dimensional.
II. Clusters cannot contain nested clusters.
III. Arrays require all elements to be of the exact same data type.
Which of the above statements is/are correct?
(A) I and III
(B) I and II
(C) II and III
(D) III only

NODIA

2004

81. How does a Waveform Graph distinguish itself from a Waveform Chart when handling a single array of numeric values?
(A) The chart completely ignores data arrays and plots only single data points
(B) The graph plots the entire array at once, replacing previous plots
(C) The graph appends the newly received array to the end of the past array
(D) The graph always requires a separate, dedicated time array to function

2019

82. Which advanced computational node is best utilized when evaluating a complex logic tree that involves extensive mathematical formatting?
(A) Case Structure
(B) While Loop
(C) Event Structure
(D) Formula Node

2017

83. Why must a developer exercise caution when utilizing Shared Variables across a wide area network?
(A) Network latency can introduce unpredictable delays in variable updates
(B) They inherently bypass all operating system security protocols
(C) They immediately corrupt any TDMS files open on the host machine
(D) They convert all floating-point numbers to strings automatically

2013

84. Which file I/O function sequence is essential for ensuring that file corruption does not occur after writing data?
(A) Open → Write → Format → Read

2015

103. If a Case Structure is wired to a Boolean control, what are the minimum required cases it must contain by default to avoid a compile error?
(A) A single default case
(B) Two cases (True and False)
(C) Three cases (True, False, and Null)
(D) Four cases (True, False, Error, and Default)

2011

104. Which of the following actions requires the use of a bundle/unbundle function?
(A) Extracting and reading the third element of a standard 1D Array
(B) Converting any high-precision floating-point number to an integer
(C) Combining variables into a single logical cluster structure
(D) Executing mathematical multiplication on two discrete spatial matrices

2019

105. When plotting two distinct arrays of data where the X and Y coordinates are independent and potentially irregularly spaced, which visualization is appropriate?
(A) Waveform Chart
(B) Waveform Graph
(C) Intensity Chart
(D) XY Graph

2017

106. In an advanced VI, what is the primary benefit of utilizing a MathScript node over standard mathematical graphical blocks for complex algorithms?
(A) It permits direct reuse of .m scripts without rewiring
(B) It runs mathematical routines significantly faster natively
(C) It completely removes the need for a host operating system
(D) It automatically generates all necessary user interface modules

2025

107. Which programming construct provides the most robust method for safely transferring data between parallel loops on the same block diagram while minimizing race conditions?
(A) Global Variables
(B) Queues or Notifiers
(C) Local Variables
(D) Shared Variables

2013

108. When writing high-speed, continuous data to a storage drive, why is it poor practice to open and close the file inside the data acquisition loop?
(A) Because it creates excessive and unnecessary internal string data conversions
(B) Because continuous file I/O operations introduce high latency
(C) Because the storage file will automatically compress itself into a ZIP format
(D) Because the physical hard drive platter will completely stop spinning

2009

109. What is the primary function of parsing an INI file at the start of a VI execution?
(A) To load configuration parameters like file paths and thresholds
(B) To send a standardized calibration electrical pulse to the DAQ hardware
(C) To locate and delete outdated application logging data files automatically
(D) To compile and build graphical source code blocks into executable formats

2017

110. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): A 4-20mA current loop can easily detect a completely broken wire in the transmission line.
Reason (R): A broken wire results in a current of 0mA, which is distinct from the 4mA signal used to represent the zero-scale value.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014

111. Which parallel interfacing standard utilizes a 24-pin connector and relies on a Controller-In-Charge to manage bus traffic?
(A) RS-485
(B) Ethernet
(C) PCI Express
(D) IEEE 488 (GPIB)

2008

112. Which statement INCORRECTLY describes the Virtual Instrument Software Architecture (VISA)?
(A) It provides a unified API for interacting with

Downloaded from www.pdf.tube

(B) The system responds slowly and heavily damps all inputs
(C) The system may become unstable and oscillate severely
(D) The integral error resets to zero permanently

2011
95. Which image processing operation is primarily used to remove high-frequency noise from a captured image in machine vision?
(A) Spatial filtering (e.g., Gaussian blur)
(B) Thresholding
(C) Edge detection
(D) Pattern matching

2001
96. What is the purpose of trajectory generation in automated motion control?
(A) To perform random stress tests on the physical motor drive hardware
(B) To monitor and measure the operational temperature of motor windings
(C) To ensure smooth speed and acceleration to a target position
(D) To write and save loop PID controller coefficients to an external file

2004
97. Which of the following represents the most fundamental difference between a traditional oscilloscope and a virtual oscilloscope?
(A) The virtual oscilloscope cannot measure voltage
(B) The virtual oscilloscope leverages a generic PC and modular DAQ for functionality defined by software
(C) The traditional oscilloscope uses software to define its buttons, while the virtual one uses physical knobs
(D) The traditional oscilloscope processes data slower than human reaction time

2022
98. Which component is responsible for isolating high-voltage signals from the sensitive computer bus in a DAQ system?
(A) The CPU
(B) The Application Software
(C) The Memory (RAM)
(D) The Signal Conditioning module

2014
99. Why is Data-Flow programming considered inherently advantageous for multi-core processors?
(A) Independent nodes can automatically execute in parallel
(B) It enforces strict sequential execution pathways, minimizing power
(C) It natively ignores physical core limitations and hardware constraints
(D) It compiles source code directly into flat binaries without optimization

2008
100. Consider the following statements regarding the VI Environment:
I. The Front Panel contains the graphical source code.
II. The Block Diagram contains Controls and Indicators.
III. Tool palettes are used to wire block diagram nodes together.
IV. Terminals on the block diagram correspond to objects on the front panel.
V. The Run button is located exclusively on the tool palette.
Which of the above statements are INCORRECT?
(A) I, II and V
(B) I, III and IV
(C) II, III, IV and V
(D) III, IV and V

2008
101. What visual cue in the Context Help window for a Sub-VI indicates that an input terminal is required for the VI to run?
(A) The terminal name is bolded
(B) The terminal icon is colored white
(C) The terminal name is written in italic text
(D) The terminal name is underlined

2009
102. What is the primary operational difference between a While Loop and a For Loop in virtual instrumentation?
(A) A While Loop can only process arrays; a For Loop can process any data type
(B) A While Loop executes infinitely regardless of conditions; a For Loop requires a Boolean input
(C) A While Loop evaluates its condition before the first execution; a For Loop evaluates after
(D) A While Loop executes based on a conditional terminal; a For Loop executes a predetermined number of times

NODIA

(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

2019
121. What is the fundamental parameter that defines the physical step distance of a stepper motor in automated motion control?
(A) The feedback proportional loop gain
(B) The image acquisition camera frame rate
(C) The serial communication port baud rate
(D) The motor's steps per revolution

2004
122. Which aspect of traditional measurement systems is directly bypassed by utilizing Virtual Instrumentation?
(A) Using fixed, vendor-defined physical instrument faceplates
(B) The basic requirement for deploying physical measurement sensors
(C) The constant requirement for operational electrical power sources
(D) The core thermodynamic and physical laws governing measurement science

2015
123. What primarily determines the overall measurement accuracy of a Virtual Instrumentation system?
(A) The display pixel resolution of the hardware monitor
(B) The quality of the sensors and DAQ conditioning hardware
(C) The clock processing speed of the host computer CPU
(D) The specific version of the local operating system

2013
124. What is a key consequence of the data-flow paradigm regarding memory management?
(A) Memory resources are never consumed by any array data operations
(B) Branching wires can duplicate data in memory if not optimized
(C) Garbage collection is manually programmed using specific text script commands
(D) All variables must be explicitly declared at the top of the block diagram

2017
125. Which element is NOT typically found on a VI's Block Diagram?
(A) User controls
(B) Sub-VI nodes
(C) Wires
(D) Control terminals

2013
126. Why is creating a modular program structure through Sub-VIs considered best practice?
(A) It guarantees that the execution thread runs only on a single CPU core
(B) It intentionally makes source code harder to read to protect logic
(C) It promotes code reuse, simplifies debugging, and reduces clutter
(D) It automatically translates and converts all active data types to strings

2019
127. What is the function of the conditional terminal in a While Loop?
(A) It determines the speed at which the loop executes
(B) It controls the color of the front panel background
(C) It automatically triggers an external hardware switch
(D) It evaluates a Boolean to control loop execution

2011
128. What execution behavior characterizes a Flat Sequence structure?
(A) All sequence frames execute simultaneously to save processing time
(B) Frames run randomly based on available operating system threads
(C) Frames execute sequentially from left to right
(D) All frames automatically execute in reverse if an error occurs

2025
129. Which operation is generally required to combine a 1D array of time values and a 1D array of amplitude values for plotting on an XY Graph?
(A) Splitting the arrays
(B) Bundling the two arrays into a Cluster
(C) Converting the arrays to strings
(D) Reversing the time array

2022
130. Consider the following statements regarding data visualization:
I. A Waveform Graph receives an entire block of data and plots it all at once.
II. A Waveform Chart is typically placed inside a loop to append single points sequentially.
III. An XY graph must receive data strictly at evenly spaced time intervals.

Click Here to Buy book on Flipkart

diverse physical instruments
(B) It simplifies migrating from serial communication interfaces to USB systems
(C) It requires memorizing register addresses for all devices
(D) It fully abstracts and handles all low-level hardware driver calls

2022
113. In analog-to-digital conversion, what phenomenon occurs if a signal is sampled at a rate lower than the Nyquist rate?
(A) Quantization noise and voltage errors decrease significantly
(B) Aliasing, generating false low frequency components
(C) The original analog signal waveform is perfectly reconstructed
(D) The hardware modules automatically apply anti-aliasing filters

2022
114. What is the fundamental difference between a standard operating system and a Real-Time Operating System (RTOS) regarding latency?
(A) RTOS always processes data faster in absolute terms
(B) Standard OS has lower jitter than RTOS
(C) RTOS requires infinite latency tolerance
(D) RTOS guarantees a strict maximum bound on response time (latency)

2021
115. In a SCADA system integrated with VI, what is the primary role of the HMI?
(A) To provide process visualization and control inputs
(B) To store historical system database records permanently
(C) To act as a primary physical sensor in the active field
(D) To compile executable source code for remote terminals

2004
116. Which of the following is typically eliminated when publishing a VI using a Remote Panel configuration over a local network?
(A) The underlying physical local area network infrastructure
(B) The operational requirement for the host PC to remain powered on
(C) Installing the full VI source code on the client computer
(D) The fundamental ability to view and interact with graphical indicators

2021
117. What is an inherent advantage of using ActiveX over standard file I/O for report generation?
(A) It allows dynamic formatting and editing of the report during runtime
(B) It requires significantly less computer processing power and system RAM
(C) It is platform-independent and runs natively on all Linux distributions
(D) It functions perfectly without requiring Microsoft Office tools installed

2005
118. Which combination of elements is LEAST relevant to developing a closed-loop control system simulation in a VI?
(A) A mathematical model of the plant
(B) A PID controller algorithm
(C) A feedback path routing output to the error calculator
(D) A string formatting function for text file headers

NODIA

2025
119. In machine vision (IMAQ), what does the term "Region of Interest" (ROI) refer to?
(A) The financial return expected from the automation system
(B) The specific area of an image isolated for processing and analysis
(C) The physical distance between the camera lens and the object
(D) The spectrum of light visible to the camera

2013
120. Match the data storage mechanisms with their typical use cases.
List I: (Mechanism)
P. TDMS File
Q. Text File
R. INI File
S. Relational Database
List II: (Use Case)
1. Cross-referencing large volumes of historical batch data
2. Storing high-speed waveform data with integrated properties
3. Logging a few slow temperature readings for human review
4. Saving application startup settings and default values
(A) P-2, Q-3, R-4, S-1
(B) P-1, Q-4, R-2, S-3

from the local network and the internet
(C) The source code must be compiled using standard ANSI C++ rather than graphical blocks
(D) The target hardware must have a dedicated local display monitor and keyboard attached

2024
140. Consider the following statements regarding SCADA:
I. SCADA systems are exclusively used for small-scale, single-room processes.
II. SCADA software heavily relies on networking to aggregate distributed data.
III. VI cannot be integrated into a SCADA architecture.
IV. SCADA inherently handles both supervisory monitoring and localized control.
Which of the above statements are INCORRECT?
(A) I and III
(B) I, II and IV
(C) II and IV
(D) III and IV

2019
141. What is the most critical security concern when configuring a VI Web Server for Remote Panels?
(A) The graphical user interface will fail to render correctly and show degraded display resolution
(B) The server application will rapidly consume excessive physical hard drive storage on the host machine
(C) The data storage pipelines will fail, causing the TDMS measurement files to corrupt automatically
(D) Unauthorized remote clients can control physical hardware if access lists are misconfigured

2014
142. Which limitation is inherent to ActiveX technology when used in Inter-Application Communication?
(A) It is strictly restricted to high-bandwidth media streaming and real-time audio processing applications
(B) It lacks the internal character encoding capability required to transfer complex string data formats
(C) It is highly platform-dependent, limiting software execution exclusively to Windows environments
(D) It requires manual configuration of dedicated physical cabling connections between software systems

2010
143. In a closed-loop system simulation, what is the mathematical function of the error signal?
(A) Set point + Process Variable
(B) Set point − Process Variable
(C) $\frac{\text{Process Variable}}{\text{Set point}}$
(D) Derivative of the Set Point

2011
144. Which hardware component dictates the spatial resolution of an acquired machine vision image?
(A) The computer's physical RAM capacity and processor clock speed
(B) The physical length and shielding quality of the interface cable
(C) The manufacturer brand and internal bus design of the DAQ module
(D) The camera sensor's pixel grid and the optical lens magnification

2001
145. What purpose does a home switch serve in an automated motion control system?
(A) It provides an absolute physical reference point to calibrate motor coordinates
(B) It disconnects primary electrical power lines to turn off the laboratory lights
(C) It monitors thermal sensors to measure the internal temperature of the controller
(D) It changes the primary network protocol dynamically from high-speed Ethernet to Serial

NODIA

2022
146. Which concept is LEAST relevant to the fundamentals of Virtual Instrumentation?
(A) Software-defined functionality
(B) Modular hardware
(C) Vacuum tube amplification
(D) Graphical user interfaces

2017
147. Which term best describes a front panel element used to provide input values to the block diagram?
(A) Control
(B) Constant
(C) Indicator
(D) Sequence Frame

2021
148. Which programming paradigm relies on nodes waiting for data tokens before execution?
(A) Object-oriented

(B) Procedural
(C) Functional
(D) Data-flow

2018

149. What visual feature on a block diagram wire signifies that it is carrying a 1D Array of numeric values rather than a scalar value?
(A) The wire is drawn using a dashed pattern instead of a solid line
(B) The wire is drawn noticeably thicker than a scalar data wire
(C) The wire utilizes a bright pink color coding on the diagram
(D) The wire flashes continuously when data flows through the node

2025

150. Consider the following statements regarding Modular Programming:
I. Sub-VIs reduce block diagram complexity.
II. Sub-VIs can be called multiple times within a main program.
III. A connector pane is required to pass data into a Sub-VI.
IV. Editing a Sub-VI icon changes its underlying mathematical functionality.
V. Hierarchical design makes debugging significantly harder.
Which of the above statements are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and V
(D) I, IV and V

2014

151. What is the fundamental characteristic of an auto-indexed output tunnel on a For Loop?
(A) It discards intermediate data and outputs only the final calculated scalar value
(B) It continuously updates and passes internal loop data directly to the front panel
(C) It formats the intermediate results and writes them directly to an external database
(D) It accumulates values from all iterations and outputs them as a consolidated array

2018

152. Which structure is explicitly required if a programmer wishes to execute specific code only when a numeric input is exactly equal to 5, and different code otherwise?
(A) Case Structure
(B) While Loop
(C) Flat Sequence
(D) Error Cluster

2017

153. What is the primary purpose of unbundling by name from a Cluster?
(A) To randomize memory access of the cluster variables to enhance security
(B) To extract specific elements using their logical labels instead of order
(C) To permanently remove selected data structures and elements from the cluster
(D) To automatically convert all numeric fields into corresponding named strings

2006

154. If a developer needs to visualize the frequency spectrum (FFT) of a signal, which indicator is most appropriate?
(A) Waveform Chart
(B) Waveform Graph
(C) Boolean LED
(D) String Indicator

2017

155. Which limitation applies to a Formula Node?
(A) It requires all variables to be explicitly declared with their data types inside the node
(B) It is computationally restricted and cannot perform basic addition or subtraction operations
(C) It requires a continuous, active internet connection to validate its mathematical libraries
(D) It is architecturally limited and cannot handle multiple input variables simultaneously

2022

156. What is the primary advantage of using a Control Reference over a Local Variable in LabVIEW?
(A) It runs in a separate thread and consumes zero CPU execution cycles on the host
(B) It processes data packets significantly faster than standard diagram wires
(C) It allows properties and methods of the front panel object to be accessed programmatically
(D) It applies built-it algorithms to mathematically filter noisy sensor signals

2008

157. Which standard VI function is utilized to convert a raw binary stream of characters from a serial port into a workable numeric value?
(A) Proportional-Integral-Derivative (PID) control algorithm functions
(B) Bundle By Name logic block for building

Downloaded from www.pdf.tube

complex cluster structures
(C) Array Size calculation function for determining dimension limits
(D) Scan From String or String To Number conversion standard functions

2025
158. Which aspect of TDMS file architecture prevents metadata from being lost if the file is moved to another computer?
(A) The database metadata is transmitted to a remote backup server automatically
(B) The TDMS file format is system-locked and fundamentally un-movable after creation
(C) The metadata is integrated directly within the same file as the raw data
(D) The metadata is encrypted and converted to an unreadable binary diagnostic blob

2014
159. Which characteristic defines the 4-20mA current loop standard?
(A) It utilizes high-frequency voltage drop measurements to communicate digital data packets
(B) A 0mA value indicates a fault or broken wire, enabling fail-safe detection
(C) It relies on high-speed single-mode fiber optic cables for noise-free transmission
(D) It is highly restricted and only effective for transmission distances under 1 meter

2004
160. Given below are two statements, one labelled as Assertion (A) and the other labelled as Reason (R).
Assertion (A): SCPI commands allow instrument control software to be somewhat independent of the specific instrument hardware.
Reason (R): SCPI defines standard syntax and command structures (e.g., "MEAS:VOLT:DC?") that many different manufacturers adopt for similar instruments.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2007
161. What does VISA act as in the software architecture of a VI?
(A) A high-level hardware abstraction layer
(B) The lowest-level hardware driver
(C) The primary graphical user interface
(D) The mathematical processor

2012
162. Which DAQ specification defines the maximum frequency at which a system can continuously take discrete measurements of an analog signal?
(A) ADC Resolution
(B) Input Range
(C) Sampling Rate
(D) FIFO Buffer Size

2025
163. In the context of Real-Time Systems, what is "jitter"?
(A) The timing deviation of a supposedly periodic deterministic task
(B) The pre-configured, intended delay interval between loop executions
(C) The unwanted high-frequency physical vibration of the target hardware
(D) The absolute maximum voltage limit measurable by the analog DAQ module

NODIA

2004
164. How does OPC (OLE for Process Control) facilitate interoperability in a manufacturing plant?
(A) By forcing all interconnected hardware instruments to utilize the exact same physical connector
(B) By strictly requiring all client and server systems to operate exclusively on Linux OS platforms
(C) By replacing all specialized programmable logic controllers (PLCs) with standard desktop PCs
(D) By providing standard software interfaces between field devices and SCADA systems

2023
165. Which network protocol is fundamentally underlying the operation of a VI Web Server?
(A) UDP
(B) HTTP/TCP
(C) GPIB
(D) RS-485

2016
166. Which of the following best describes an ActiveX Control embedded in a VI Front Panel?
(A) A native, vector-based graphical indicator drawn dynamically by the development software
(B) A physical, manual hardware switch wired directly to an external digital DAQ board

(B) Bundle By Name
(C) Set File Position (seek to end)
(D) Scan From File

2001

207. What specific structural advantage does a TDMS file have that allows for rapid searching of historical data?
(A) It optimizes storage by strictly limiting individual file sizes to under 1 MB
(B) It uses a separate hierarchical index of properties apart from raw data blocks
(C) It relies internally on software spreadsheet engines to query and render searches
(D) It stores all telemetry data structures as highly simple, uncompressed ASCII text

2012

208. Which communication standard utilizes current rather than voltage to transmit signals?
(A) RS-232
(B) GPIB
(C) USB
(D) 4-20mA loop

2023

209. In GPIB communications, what is the maximum number of devices typically allowed on a single standard bus?
(A) 5
(B) 15
(C) 127
(D) 255

2024

210. Given below are two statements, one labelled as Assertion (A) and the other labelled as Reason (R).
Assertion (A): Instrument drivers drastically reduce the development time required for virtual instrumentation applications.
Reason (R): Instrument drivers abstract the complex, low-level SCPI command strings into simple, pre-configured graphical functions.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2022

211. Which data acquisition feature is utilized to capture a signal immediately preceding a specific event?
(A) Pre-triggering with a circular buffer
(B) Analog output
(C) Multiplexing
(D) Filtering

2004

212. Which architecture is defined by an embedded processor running a real-time OS connected to a reconfigurable FPGA?
(A) Standard Desktop PC
(B) Basic USB DAQ
(C) GPIB Controller
(D) NI CompactRIO (cRIO)

2008

213. In SCADA, what is the process of collecting data from remote locations called?
(A) Actuation
(B) Telemetry / Data Acquisition
(C) Rasterization
(D) Compiling

2015

214. Which feature is essential for a Remote Panel client to fully interact with a VI running on a host server?
(A) The client must have write access to the host's hard drive
(B) The client must be on a different continent
(C) Request Control permission must be granted by the host
(D) The host VI must be completely stopped

2022

215. Which COM methodology enables a VI to dynamically generate a PDF report using an external installed application?
(A) Direct hardware writing
(B) UDP broadcasting
(C) RS-485 serial communication
(D) ActiveX Automation

2011

216. Which system dynamic dictates how quickly a simulated PID control loop reaches its final setpoint?
(A) Settling Time
(B) Jitter
(C) Nyquist Rate
(D) Baud Rate

2022

217. In basic image processing, what is morphological dilation used for?
(A) To compress the spatial dimensions and reduce memory footprint of the image file
(B) To expand and link adjacent bright pixel

Click Here to Buy book on Amazon

computer

2001

176. Which loop structure inherently possesses a conditional terminal that must be wired for the program to be executable?
(A) For Loop
(B) Timed Loop
(C) MathScript Loop
(D) While Loop

2018

177. When placing an Event Structure, what is the default behavior if an unconfigured event occurs?
(A) The event is ignored unless the structure is explicitly configured to handle it
(B) The structure intercepts the unregistered event and triggers an execution failure
(C) The currently running VI halts operations and terminates execution immediately
(D) The software generates an unhandled exception and produces a random numeric value

2019

178. What is the primary operational advantage of storing data in an Array rather than utilizing numerous individual scalar variables?
(A) Arrays are highly optimized structures that consume zero physical memory space
(B) Arrays are heterogeneous, allowing conflicting data types to be grouped together
(C) Arrays enable programmatic iteration, sorting, and vector operations on datasets
(D) Arrays possess built-it automated background routines to write directly to disk

2005

179. Which data visualization element is essentially a 2D array of colors mapped to a 2D array of numeric values?
(A) Intensity Graph
(B) Waveform Graph
(C) Scatter Plot
(D) Boolean Array

2014

180. Which of the following is the correct development sequence for integrating a DLL function into a VI using the Call Library Function Node?
(A) Run the VI → Select DLL path → Define parameters → Wire terminals
(B) Place the node → Select DLL path and configure parameters → Wire the inputs and outputs → Run the VI
(C) Wire the inputs and outputs → Run the VI → Select DLL path → Define parameters
(D) Select DLL path → Run the VI → Place the node → Wire terminals → Define parameters

2009

181. Which variable type is designed to minimize the risk of race conditions by utilizing a first-in, first-out (FIFO) buffer mechanism for passing data between loops?
(A) Global Variable
(B) Queue
(C) Local Variable
(D) Shared Variable

2014

182. Which function is LEAST likely to be used when writing formatted data to a spreadsheet string file?
(A) Array to Spreadsheet String
(B) Open/Create/Replace File
(C) Threshold Image
(D) Write Text File

2015

183. Which file extension designates a self-describing, binary format specifically optimized for storing measurement data?
(A) .csv
(B) .txt
(C) .ini
(D) .tdms

NODIA

2002

184. In serial communication, what is the purpose of parity bits?
(A) To provide basic error detection during data transmission
(B) To increase the overall throughput and transmission speed
(C) To provide operational electrical power to the receiver
(D) To define the logical termination point of the message

2018

185. Which standard provides a universally understood syntax for asking an instrument to identify itself (e.g., “*IDN?”)?
(A) IEEE 802.3 Ethernet
(B) IEEE 488.2 / SCPI
(C) USB 3.0 Standard
(D) TIA/EIA RS-232

(C) The size of the computer monitor
(D) A thick, resizable rectangular frame

2015
245. Which of the following is NOT fundamentally governed by the Data-Flow programming paradigm?
(A) Execution order of independent parallel loops
(B) The physical RAM clock speed of the PC
(C) Execution order of sequentially wired nodes
(D) The propagation of variables through shift registers

2011
246. What visual element on a graphical node indicates that an input requires a boolean data type?
(A) The terminal is colored orange
(B) The terminal is colored blue
(C) The terminal is colored green
(D) The terminal is colored pink

2022
247. Which feature dictates the mapping of front panel controls and indicators to the input and output terminals of a Sub-VI?
(A) The Icon Editor
(B) The Tool Palette
(C) The Property Node
(D) The Connector Pane

2010
248. What logic error is most likely to occur if an uninitialized shift register is used in a While Loop that is stopped and restarted?
(A) The shift register retains and uses the final value from the previous run
(B) The compiler halts code analysis and the parent loop refuses to execute
(C) The loop execution freezes, forcing the controller to execute infinitely
(D) The VI development environment converts the shift register to a feedback node

2016
249. Which structure is ideal for running specific cleanup code only when the main program stops or errors out?
(A) A For Loop
(B) A Case Structure wired to an error cluster status
(C) A MathScript Node
(D) An Event Structure

2001
250. How does indexing an array at a loop tunnel differ from passing it through as a solid array?
(A) Indexing permanently deletes the array in memory; passing a solid array saves it to disk
(B) Indexing passes one element per iteration; passing solid array processes the whole array at once
(C) Indexing converts the array to a text string; passing a solid array retains its numeric data type
(D) There is absolutely no operational or performance difference between these two tunnel types

2019
251. Which visualization is used primarily to plot 3D data where X and Y are coordinates and Z is represented by color?
(A) Intensity Graph
(B) XY Graph
(C) Waveform Chart
(D) Digital Display

2015
252. Which integration method is required to utilize a custom-compiled C++ function (`.dll`) within a VI?
(A) MathScript Node
(B) ActiveX Automation
(C) Call Library Function Node
(D) System Exec Node

2025
253. Which variable handling technique violates the strict data-flow paradigm but is sometimes necessary for complex, multi-window UI architectures?
(A) Wires
(B) Shift Registers
(C) Auto-indexed tunnels
(D) Local / Global Variables

2007
254. When reading a large spreadsheet file into a VI, what function is critical to properly separating the data columns?
(A) A generic numeric Add function block on the block diagram
(B) A Boolean threshold operator to isolate specific data spikes
(C) Spreadsheet String to Array, configured with the correct delimiter
(D) A Fast Fourier Transform algorithm block to analyze frequencies

Downloaded from www.pdf.tube

without real hardware
(C) A software design methodology focusing on writing text-based assembly code for embedded microcontrollers
(D) A legacy development concept that has been entirely replaced by modern dedicated hardwired benchtop meters

2022
196. Which component is entirely software-defined in a Virtual Instrument?
(A) The physical signal conditioning amplifier hardware
(B) The hardware-defined analog sampling rate limits
(C) The external sensor's physical transducer mechanism
(D) The graphical front panel and signal analysis logic

2009
197. Which of the following indicates that a data-flow program is incapable of execution?
(A) The block diagram is completely blank
(B) The Run button on the toolbar is shown as a broken arrow
(C) The front panel has no controls
(D) A wire is colored green

2017
198. Which tool is utilized to debug a VI by slowing down execution and visualizing the flow of data across wires?
(A) The Error Cluster
(B) The Operating Tool
(C) Highlight Execution (the lightbulb button)
(D) A Formula Node

2019
199. What dictates the overall visual layout of a Sub-VI's terminals when wiring it in a main program?
(A) The size of the Sub-VI's front panel
(B) The number of loops inside the Sub-VI
(C) The alphabetical order of the variables
(D) The specific pattern selected for the Connector Pane

2005
200. What is the fundamental requirement for transferring a value from one iteration of a While loop to the very next iteration?
(A) A Shift Register or Feedback Node
(B) A Global Variable
(C) An Auto-indexed tunnel
(D) An Event Structure

2019
201. Which control structure inherently forces a strict chronological sequence of operations regardless of data flow?
(A) While Loop
(B) Flat Sequence Structure
(C) Case Structure
(D) MathScript Node

2014
202. What is the result of wiring an Array of 5 elements and an Array of 10 elements into an Add function?
(A) A compiler error occurs, immediately halting and preventing code execution
(B) An array of 5 elements is created, matching the size of the smaller array
(C) A unified array containing 15 combined elements is automatically generated
(D) An array of 10 elements is created, padding the smaller array with zero values

2022
203. Which front panel indicator is best suited for plotting a complete array of pre-acquired data points and natively supports zooming and panning?
(A) Waveform Chart
(B) Waveform Graph
(C) Boolean LED
(D) Numeric Indicator

2009
204. Which advanced node allows a developer to directly type mathematical expressions like `` `y = a * x^2 + b` ``?
(A) Call Library Function Node
(B) Property Node
(C) Formula Node
(D) Invoke Node

NODIA

2025
205. Which variable scope is necessary to seamlessly share data over a network between two completely separate VI applications running on different machines?
(A) Application-scope Local Variable
(B) VI-level single-process Global Variable
(C) Standard Block Diagram Wire connection
(D) Network-Published Shared Variable

2013
206. Which file operation must be performed to read the very end of a continuously appended text file without reading the entire file?
(A) Format Into String

(C) A reusable component from another application operating inside the VI
(D) A static, non-interactive raster image file imported into the front panel background

2023
167. Which process parameter is the integral term of a PID controller attempting to minimize?
(A) The instantaneous rate of change of the error signal
(B) The maximum amplitude of the initial system overshoot
(C) The high-frequency electrical noise in the sensor line
(D) The accumulated steady-state offset error over time

2017
168. Which image processing technique relies on comparing acquired images against a known reference template?
(A) Pattern Matching
(B) Edge detection
(C) Thresholding
(D) Color inversion

2022
169. What is a typical application of contouring in automated motion control?
(A) Driving a single independent motion axis from point A to point B at peak velocity
(B) Coordinating multiple axes to follow a complex, curved geometric path
(C) Continuous monitoring of thermal sensors on a stationary motor frame
(D) Triggering emergency deceleration mechanisms to stop the motor instantly

2021
170. Match the graphical programming concepts with their textual programming equivalents.
List I: (Graphical Programming Concepts)
P. Block Diagram Wire
Q. For Loop Auto-indexing
R. Sub-VI
S. Case Structure
List II: (Textual Equivalents)
1. Switch / If-Else Statement
2. Function Call
3. Variable / Data Passing
4. Array Iteration
(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-4, Q-1, R-3, S-2
(D) P-1, Q-2, R-4, S-3

2009
171. Which statement best encapsulates the primary function of a PC in Virtual Instrumentation?
(A) It runs the software that performs analysis, user interface, and system control
(B) It acts strictly as a continuous DC power supply source for the DAQ hardware module
(C) It handles physical attenuation and high-voltage conditioning of analog input signals
(D) It limits the monitoring system strictly to low-speed, single-channel measurements

2024
172. Which of the following identifies an INCORRECT application of Virtual Instrumentation?
(A) Automated high-throughput testing and diagnostics of complex printed circuit boards
(B) Continuous real-time thermal monitoring of high-pressure industrial boiler systems
(C) Directly driving heavy mechanical loads without intermediate motor amplifiers
(D) Rapid prototyping and software implementation of advanced medical imaging algorithms

2002
173. What fundamental rule of data-flow programming determines when a loop iteration finishes?
(A) When a specific software-based delay timer reaches zero and expires
(B) When the operator performs a click event on the graphical front panel
(C) When the first node in the execution sequence completes its operation
(D) When all nodes inside the loop have finished execution and produced output data

2013
174. Which tool palette element is required to change the specific text displayed on a Boolean push-button control?
(A) Operating tool
(B) Wiring tool
(C) Labeling / Text tool
(D) Probe tool

2022
175. What is the immediate consequence of leaving a required input terminal unwired on a Sub-VI?
(A) The calling VI will execute using a default zero value
(B) The calling VI will become broken and refuse to run
(C) The Sub-VI will automatically remove the unused port
(D) The application will crash the local host

Click Here to Buy book on Flipkart

regions within a binary thresholded image
(C) To shrink and completely eliminate small noise-related bright spots in the image
(D) To convert a standard multi-channel color image into a single-channel grayscale map

2004
218. What defines the trajectory "profile" in automated motion control?
(A) The physical design and exterior paint color of the motor protective casing
(B) The pre-calculated profile curve of target velocity plotted against time
(C) The specific text-based software programming language utilized by the engineer
(D) The maximum available bandwidth limits of the industrial communication network

2024
219. Which statement INCORRECTLY characterizes the evolution of Virtual Instrumentation?
(A) It relies entirely on analog calculation methods
(B) It moved from fixed-function hardware to flexible, software-defined systems
(C) It heavily leveraged the rapid advancement of commercial PC computing power
(D) It facilitated the integration of measurement and control into single environments

2008
220. Match the VI Environment component with its specific function.
List I: (VI Environment Component)
P. Block Diagram
Q. Front Panel
R. Context Help
S. Probe Tool
List II: (Function)
1. Displays real-time data values on a wire during execution
2. Houses the graphical source code and wiring
3. Serves as the user interface for controls and indicators
4. Provides instant documentation for hovered nodes
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-4, Q-1, R-3, S-2
(D) P-2, Q-4, R-1, S-3

2003
221. What happens when a graphical node possesses an error input and an error output terminal, and an error is passed into it?
(A) The node initiates internal diagnostic routines to automatically fix the incoming error
(B) The node executes its primary function normally but flags the warning on its output port
(C) The execution engine halts operations and crashes the entire VI application immediately
(D) The node bypasses execution and passes the incoming error directly to its output port

2017
222. Which structural configuration is best for executing different initialization, acquisition, and shutdown states in a specific, flexible order?
(A) A single, un-nested While Loop executing continuously without conditional branching
(B) A sequential Flat Sequence structure that executes frames strictly from left to right
(C) A State Machine architecture linking a While Loop and a multi-frame Case Structure
(D) A single MathScript Node loaded with sequential script lines

2024
223. What is the fundamental reason hierarchical program design (Sub-VIs) is emphasized in virtual instrumentation?
(A) To increase the overall physical storage footprint of compiled executable files
(B) To abstract system complexity and enable modular, readable, and reusable code
(C) To systematically bypass standard data-flow compiler execution rules in the VI
(D) To programmatically disable external hardware communication ports on demand

2004
224. Which loop structure is best suited for iterating over every element of an incoming array automatically?
(A) A While Loop configured with a manual stop button
(B) A highly precise, hardware-synchronized Timed Loop
(C) A standard Shift Register-driven State Machine loop
(D) A For Loop configured with Auto-Indexing enabled

2013
225. Which control structure in LabVIEW executes a specific subdiagram (case) based on the value passed to its selector terminal?
(A) Case Structure

Downloaded from www.pdf.tube

2004
186. Which tool represents the highest level of abstraction for communicating with a benchtop instrument in a VI?
(A) Low-level direct hex register writing
(B) Plug-and-play Instrument Driver VIs
(C) Raw, manual VISA Write/Read strings
(D) Interactive configuration utilities

2011
187. What does the term "multiplexing" refer to in the context of a DAQ system?
(A) Sequentially switching a single ADC to sample multiple input channels
(B) Utilizing multiple parallel ADCs to sample a single input channel only
(C) Broadcasting the acquired measurement data over the public internet
(D) Increasing the input voltage measurement range dynamically in software

2019
188. Which component is vital for ensuring the precise timing and determinism of a Real-Time OS?
(A) A dedicated high-end graphics rendering card with local memory buffers
(B) A high-speed wireless internet connection for continuous remote access
(C) A high-resolution hardware timer with priority interrupt scheduling
(D) A high-capacity mechanical hard drive with fast disk access rotation

2021
189. Which industrial protocol is most universally recognized for facilitating tag-based data exchange between SCADA nodes and PLCs?
(A) SMTP
(B) FTP
(C) HTTP
(D) OPC

2010
190. What is the correct sequence of steps to configure and deploy a VI Remote Panel?
I. Open the web browser on the client machine and enter the URL.
II. Enable the Web Server in the VI host application settings.
III. Configure the Web Server access lists for allowable clients.
IV. Publish the specific VI to the Web Server using the Web Publishing Tool.
(A) II, III, IV, I
(B) I, II, III, IV
(C) III, II, IV, I
(D) IV, III, II, I

2009
191. When utilizing Inter-Application Communication to automate Excel, which concept represents a specific Excel workbook or worksheet within the code?
(A) A Formula Node structure
(B) An ActiveX Object Reference
(C) A raw TCP Socket connection
(D) A Local Variable instance

2009
192. Which characteristic defines an open-loop control system in contrast to a closed-loop system?
(A) It runs processes much faster by bypassing hardware-level handshaking
(B) It relies on a significantly more complex multi-variable PID algorithm
(C) It simplifies programming by utilizing global variables almost exclusively
(D) It operates without utilizing sensor feedback to adjust its control output

2006
193. In image acquisition, what is a primary function of a frame grabber?
(A) To capture and buffer continuous image frames in computer memory at high speed
(B) To automatically convert a digital image stream into a physical paper printout
(C) To compress acquired visual data directly into a standard JPEG format only
(D) To programmatically adjust the intensity of physical light sources in the room

NODIA

2014
194. What is the role of the derivative term in a PID position control loop?
(A) To fully eliminate steady-state error through continuous offset correction
(B) To generate a strong initial starting kick to overcome mechanical stiction
(C) To damp system oscillations by predicting future trend lines of the error
(D) To continuously increase rotational velocity towards maximum possible limits

2021
195. Which statement accurately defines the concept of Virtual Instrumentation?
(A) A system combining computers, modular hardware, and flexible software for custom measurement and control
(B) An interactive simulation of complex electrical circuits and instrumentation setups

2014

235. Which DAQ module specification directly limits the highest frequency analog signal that can be faithfully captured?
(A) Maximum Sampling Rate
(B) Input impedance
(C) Buffer size
(D) Resolution

2001

236. What is the primary advantage of utilizing an Embedded Controller with an RTOS over a standard Windows PC for industrial control?
(A) It features superior integrated graphics processing power for local screen rendering
(B) It completely eliminates any requirement for writing low-level software programs
(C) It ensures deterministic execution free of operating system background interruptions
(D) It supports direct plug-and-play connections of standard desktop computer mouse units

2009

237. Which function is critical for integrating VI applications into standard enterprise IT databases?
(A) Fast Fourier Transforms (FFT)
(B) Edge Detection
(C) RS-232 Configuration
(D) OLE DB / ODBC Database Connectivity

2008

238. What is necessary to view a published Remote Panel if the client machine does not have the VI development environment installed?
(A) A specialized, licensed physical hardware security dongle key
(B) An active, hardwired GPIB cabling connection to the host server
(C) The local Run-Time Engine and a compatible web browser plugin
(D) A pre-installed, fully functional C++ compiler on the client

2024

239. Which node specifically interacts with COM objects to execute methods or set properties in external applications like Microsoft Word?
(A) MathScript Nodes running textual matrix code
(B) Property or Invoke Nodes wired to an Automation Refnum
(C) Call Library Function Nodes targeting system DLLs
(D) Formula Nodes executing basic algebraic formulas

2019

240. What is the correct sequence for closing a control loop using a VI?
I. Read the Process Variable from the DAQ input.
II. Calculate the Error (Set po int − Process Variable).
III. Apply the PID algorithm to determine the control action.
IV. Write the Control Output to the DAQ analog out.
(A) I, II, III, IV
(B) II, I, III, IV
(C) I, III, II, IV
(D) IV, III, II, I

2018

241. Which algorithm is most relevant for identifying the precise center coordinates of a circular object in machine vision?
(A) Pattern matching / Geometric matching
(B) Image Thresholding
(C) Spatial filtering
(D) Image cropping

2004

242. In automated motion control, what is a "stepper" motor's defining operational characteristic compared to a standard DC motor?
(A) It operates exclusively on high-voltage alternating current (AC) power lines
(B) It inherently utilizes wireless links and requires zero physical cabling
(C) It rotates in discrete angular steps triggered by digital pulse inputs
(D) It provides absolute, step-free continuous velocity at all speed ranges

2005

243. Which statement accurately reflects an advantage of software-defined virtual instrumentation?
(A) Measurement features can be modified in software without altering physical hardware
(B) Hardware measurement components cannot be updated or upgraded after initial purchase
(C) Software-based execution processes introduce zero latency under all load conditions
(D) It restricts developers, forcing them to rely entirely on vendor-defined panels

2012

244. What defines the physical boundary of a block diagram structure, such as a For Loop?
(A) A specific text command at the beginning and end
(B) The color of the wires passing through it

Click Here to Buy book on Amazon

(B) Stacked Sequence Structure
(C) For Loop
(D) Formula Node

2015
226. What does bundling multiple data types into a single Cluster essentially achieve in a block diagram?
(A) It significantly increases execution speed by optimizing compiled machine code execution
(B) It automatically converts all input elements into highly portable string formats
(C) It reduces diagram wire clutter by combining multiple wires into a single trunk
(D) It permanently locks the structured cluster data elements from being modified in memory

2007
227. Which front panel indicator behaves like a paper strip chart, continuously appending and displaying new data points as they are received in real time?
(A) Waveform Chart
(B) XY Graph
(C) Intensity Graph
(D) Numeric Array

2010
228. Which application is LEAST suited for a MathScript Node?
(A) Rapid software prototyping and verification of linear algebra algorithms
(B) Directly importing and reusing legacy text-based script files
(C) Executing highly complex matrix and multi-dimensional vector calculations
(D) Achieving deterministic, microsecond-level real-time hardware control

2017
229. Which variable type is intrinsically tied to a specific front panel object and allows reading/writing its value without physical wires?
(A) Shared Variable
(B) Local Variable
(C) Global Variable
(D) Environment Variable

2003
230. Which of the following is the correct sequence for writing a 1D array of numeric values to a simple comma-separated text file?
(A) Array to Spreadsheet String → Open File → Close File → Write to Text File
(B) Write to Text File → Open File → Array to Spreadsheet String → Close File
(C) Open File → Array to Spreadsheet String → Write to Text File → Close File
(D) Open File → Write to Text File → Array to Spreadsheet String → Close File

2008
231. Which of the following represents a major disadvantage of standard INI configuration files?
(A) They are highly accessible and very easy for humans to read and manually edit
(B) They organize configuration parameters logically into nested keys and sections
(C) They are simple structures that can be easily parsed programmatically by VIs
(D) They are highly inefficient for storing massive, high-speed sensor datasets

NODIA

2011
232. What dictates the necessity of a termination resistor in an RS-485 serial network?
(A) To suppress signal reflections at transmission line ends
(B) To prevent physical system damage from transient over-voltages
(C) To supply continuous electrical power to the receiving nodes
(D) To convert incoming serial data streams into parallel formats

2008
233. What is the fundamental communication methodology used on a GPIB bus?
(A) Asynchronous serial transmission using dedicated start and stop framing bits
(B) 8-bit parallel, byte-serial asynchronous transfer with handshaking lines
(C) High-speed Ethernet packet streaming over dedicated network interface cards
(D) Fiber optic light pulse modulation transmitting across glass cable networks

2024
234. In Virtual Instrumentation, VISA resource names (e.g., "ASRL1::INSTR" or "GPIB0::14::INSTR") are used primarily for what?
(A) Specifying and configuring the transmission baud rate of serial connections
(B) Specifying the hardware port and instrument the software communicates with
(C) Declaring and initializing custom local variables inside the block diagram
(D) Setting and modifying the background color of the graphical front panel

2016

255. What structural feature of TDMS makes it superior to standard text logs for analyzing multiple tests?

(A) It automatically encrypts the raw measurement data to ensure complete security

(B) It organizes data into hierarchical groups and channels with searchable metadata

(C) It strips out all timing and timestamp information to save local hard drive space

(D) It utilizes virtualized indexing structures that require no local hard drive space

2017

256. What distinguishes a 4-20mA loop from a 0-20mA loop in industrial instrumentation?

(A) The 4-20mA loop utilizes high-frequency alternating current (AC) voltage signals

(B) The 4-20mA loop is highly distance-restricted and cannot transmit over 10 meters

(C) The 4-20mA loop utilizes a three-wire topology with a dedicated shield ground

(D) The 4-20mA loop offers a live zero (4mA) to reliably detect broken wire faults

2015

257. Which standard defines the physical layer and electrical specifications for GPIB?

(A) IEEE 488.1

(B) IEEE 802.11

(C) RS-232

(D) USB 3.0

2007

258. Which of the following is true regarding VISA architecture?

(A) It restricts and strictly limits instrumentation communication to internal PCI slots

(B) It eliminates any requirement for physical connection cabling through wireless links

(C) It handles serial, GPIB, USB, and Ethernet instruments through a unified API

(D) It functions as a bare-metal hypervisor that replaces the operating system entirely

2011

259. What DAQ hardware component fundamentally determines the maximum voltage the device can safely measure?

(A) The analog input range / programmable gain amplifier

(B) The sampling rate

(C) The digital-to-analog converter

(D) The multiplexer

2021

260. Which application relies most critically on a deterministic RTOS rather than a general-purpose OS?

(A) Logging environmental temperatures once per hour

(B) Generating a daily automated summary report on disk

(C) Updating a graphical user interface text box display

(D) Executing closed-loop millisecond turbine control

2014

261. In an OPC architecture, what does the client application do?

(A) It interfaces directly with raw memory registers of the destination hardware PLC

(B) It requests and consumes data from an OPC Server regardless of underlying hardware

(C) It handles the physical signal conditioning of incoming analog telemetry voltages

(D) It solely manages network layer routing tables for interconnected system cables

2006

262. Which mechanism allows a VI to actively push data to an external email address upon an alarm condition?

(A) TCP Listen Node

(B) Call Library Function

(C) SMTP (Simple Mail Transfer Protocol) Send functions

(D) ActiveX Server

2009

263. When using ActiveX to control Microsoft Word from a VI, what is the required initialization step?

(A) Terminate and close any active Word applications

(B) Format the target command string into a byte array

(C) Compile the active VI into a standalone dynamic DLL

(D) Open an Automation Reference to the Word class

2006

264. What happens to a simulated PID loop if the process dead-time significantly exceeds the loop execution time?

(A) The controller may over-correct, causing instability if not tuned for the delay

(B) The loop gains speed rapidly and the execution timing becomes infinitely fast

Downloaded from www.pdf.tube

graphs that plot entire arrays at once, the chart maintains and displays past data points, making it highly effective for real-time monitoring of slowly changing physical variables.

10. (A) Both A and R are true and R is the correct explanation of A.
Formula nodes allow developers to implement complex mathematical equations using standard text-based programming syntax directly within graphical code. An integrated text-based parser interprets these equations during execution, which eliminates the need to connect numerous individual graphical arithmetic blocks. This capability keeps the block diagram organized, clean, and easy to maintain during development.

11. (B) Shared Variable - Transfers data across the network or between separate VIs
Shared variables provide a robust mechanism for transferring data between different virtual instruments or across a network to separate computer systems. This capability enables distributed applications to communicate seamlessly. In contrast, local variables are restricted to a single virtual instrument, and global variables transfer data between different loops within the same local memory space.

12. (B) TDMS File - Unstructured flat file format without built-in metadata support
Technical Data Management Streaming files are structured binary files explicitly designed to store high-speed measurement data alongside descriptive metadata. This hierarchical structure organizes data into logical groups and channels while embedding properties directly into the file. Therefore, describing them as flat, unstructured files without metadata support is inaccurate, as self-description is their defining advantage.

13. (A) It includes self-describing metadata alongside raw data streams
The primary advantage of the technical data management streaming format is its ability to embed self-describing metadata directly alongside raw measurement data streams. This structure organizes measurements into hierarchical levels containing files, groups, and individual channels. It simplifies long-term data archiving by ensuring that sensor calibration and test conditions remain permanently associated with raw datasets.

14. (C) It uses differential signaling to enable multi-drop networking
The RS-485 serial standard utilizes differential signaling across balanced transmission lines, which provides outstanding immunity to electromagnetic interference and common-mode noise over long distances. This electronic design allows the protocol to support multi-drop networking configurations, enabling multiple transmitters and receivers to connect and communicate reliably on the same physical, shared industrial bus network.

15. (D) A standard text-based command language for programmable instruments
Standard Commands for Programmable Instruments defines a unified, text-based command language utilized to control measurement equipment. This standardized syntax allows computers to send commands to instruments from different manufacturers over interfaces like GPIB, USB, or Ethernet. It ensures that functions such as voltage measurements use the same command structure across diverse instrument models.

16. (C) To provide a high-level API that abstracts hardware communication
Virtual Instrument Software Architecture serves as a standardized, high-level application programming interface that abstracts communication with physical instruments. It provides a unified system command structure for interacting with devices over diverse physical interfaces, including GPIB, serial, USB, and Ethernet. This abstraction simplifies software development by eliminating the need to write custom low-level driver protocols.

17. (B) Twice the highest frequency component in the signal
The Nyquist-Shannon sampling theorem dictates that to accurately reconstruct an analog signal without aliasing, the sampling rate must exceed twice the highest frequency component present in that signal. Sampling below this critical threshold causes high-frequency elements to appear as false low-frequency signals, corrupting the measurement data during the analog-to-digital conversion process.

NODIA

ANSWERS

1. (B) Flexibility to define instrument functions through user-defined software
Virtual instrumentation shifts the primary functionality of traditional hardware-defined instruments onto software-driven solutions. This approach allows engineers to customize measurement processes, user interfaces, and data analysis routines using flexible, user-defined computer applications. Consequently, system modifications require simple program updates rather than expensive, time-consuming hardware replacements, significantly enhancing scalability and operational efficiency.

2. (D) The Data Acquisition Hardware
Data acquisition hardware serves as the essential physical bridge connecting analog sensors to computer systems. It receives physical signals, performs necessary signal conditioning, and converts analog inputs into binary formats that computer software can process. This module ensures accurate digitization of physical phenomena, enabling real-time analysis and visualization within virtual instrumentation frameworks.

3. (A) Execution is strictly sequential line-by-line
Data-flow programming structures execution based on the availability of input data rather than a sequential line-by-line instruction counter. A node within this paradigm only executes when all of its required inputs receive data. This behavior inherently enables simultaneous execution of independent paths, optimizing performance across modern multi-core computing architectures without manual synchronization.

4. (C) To provide the primary user interface with controls and indicators
The front panel of a virtual instrument serves as the graphical user interface that allows operators to interact with the application. It contains controls, such as knobs, buttons, and dials for inputting parameters, alongside indicators like graphs, charts, and LEDs to display output data. This layout mimics physical instrument faces for intuitive user control.

5. (A) The Sub-VI acts as a modular function call within the block diagram
Integrating a sub-VI into a main virtual instrument creates a modular, hierarchical program structure analogous to calling a subroutine in text-based programming languages. The sub-VI processes inputs provided by the main program and returns outputs through its connector pane. This modularity improves code readability, simplifies debugging, and promotes efficient reuse across development.

6. (D) While Loop
A while loop is the ideal control structure when an operation must run repeatedly until a specific condition evaluates to true or false. Because the exact number of iterations is unknown beforehand, this structure evaluates its conditional terminal after each cycle to decide whether to stop. This makes it highly suitable for continuous, event-driven monitoring applications.

7. (B) It visually overlaps frames to conserve block diagram space
A stacked sequence structure executes its frames sequentially from first to last, but visually overlaps them on top of each other. This layout dramatically conserves valuable block diagram space compared to flat sequence structures, which lay frames out side-by-side. However, it can make tracking data flow between different sequential steps more difficult.

8. (C) A Cluster groups mixed data types, while an Array groups elements of the same type
Arrays and clusters are complex data structures used to organize variables within virtual instruments. An array groups elements of the exact same data type, which is ideal for uniform data sequences. Conversely, a cluster groups multiple elements of varying data types, acting similarly to a struct in text-based programming to simplify wire routing.

9. (D) Waveform Chart
A waveform chart is a specialized data visualization tool designed to display continuously acquired single-point data by appending new values to a historical buffer. Unlike standard

Click Here to Buy book on Flipkart

range is divided into four thousand ninety-six discrete levels. Calculating this division yields an approximate measurement resolution of two point four four millivolts, representing the smallest voltage change detectable by the system.

66. (D) Windows task scheduling is non-deterministic, risking missed deadlines
Standard desktop operating systems like Windows prioritize user interface responsiveness and general application throughput over strict task determinism. Their thread scheduling algorithms are inherently non-deterministic, introducing unpredictable latencies and jitter. This behavior makes them unsuitable for hard real-time systems, where missing an execution deadline, even by milliseconds, can lead to severe system failure.

67. (A) Process graphics and operator controls
The design of a human-machine interface in industrial automation focuses primarily on providing intuitive process graphics and interactive operator controls. It represents complex industrial operations visually, displaying real-time data like temperatures, pressures, and status indicators. This presentation allows plant personnel to easily monitor equipment, input parameters, and initiate system commands safely.

68. (C) Configuring the VI Web Server to publish a Remote Panel
To continuously view and interact with a virtual instrument's front panel from a remote web browser, the most effective method is publishing it as a remote panel. This configuration allows a web server to stream the live graphical interface over the network, providing remote users with real-time visualization and full operational control without complex programming.

69. (A) ActiveX / COM
Generating automated reports in word processing programs like Microsoft Word from a virtual instrument is typically achieved using ActiveX and Component Object Model protocols. This technology allows the measurement software to function as a client that establishes control over the word processor, programmatically opening templates, inserting data tables, and formatting text seamlessly during runtime.

70. (A) P-3, Q-4, R-1, S-2
Proportional action reacts to the current magnitude of the system error, while integral action eliminates steady-state errors by accumulating past errors over time. Derivative action acts as a predictor, analyzing the rate of change of the error, and the setpoint represents the desired target value for the entire control loop. This mapping represents correct PID control.

71. (B) Transferring image pixel data directly to PC memory
In the context of machine vision using IMAQ, hardware interfacing is primarily concerned with establishing high-speed communication channels to transfer acquired image pixel data from a camera directly to computer memory. This interface handles parameters like frame rates, trigger signals, and pixel resolutions, ensuring raw visual information is available for software processing.

72. (C) Network IP address of the HMI
Configuring a motion axis involves setting parameters directly related to mechanical movement, feedback tracking, and system protection. This includes encoder resolutions, gear ratios, acceleration limits, and hardware safety switches. The network IP address of the human-machine interface is a higher-level network configuration and is not a parameter defined during low-level physical axis configuration.

73. (D) Separation of measurement hardware from the software
The most significant evolutionary advancement of virtual instrumentation over traditional benchtop instruments is the complete separation of measurement hardware from control software. Traditional devices bound analysis and display features directly to hardware circuits. Virtual instruments utilize modular hardware solely for physical signal translation, allowing standard computers and customized software to execute all processing and visualization.

74. (A) The Signal Conditioning module
A signal conditioning module is required to prepare raw, noisy, or low-voltage sensor outputs for reliable digitization by an analog-to-digital converter. This hardware performs vital electronic tasks such as filtering high-frequency noise, isolating dangerous voltages,

NODIA

18. (D) It provides deterministic task execution with bounded maximum response times
A real-time operating system is characterized by its ability to guarantee deterministic task execution with strictly bounded maximum response times. Unlike general-purpose operating systems that prioritize average processing throughput, this specialized system ensures that critical operations, such as closed-loop control or safety monitoring, always execute within precise, predictable time limits to prevent system failures.

19. (A) Supervisory Control and Data Acquisition
The acronym SCADA stands for Supervisory Control and Data Acquisition. This industrial automation architecture utilizes computer systems, networked data communications, and graphical user interfaces to perform high-level process supervisory management. It interfaces with programmable logic controllers and discrete sensors to monitor machinery and execute operational control decisions across large industrial facilities.

20. (A) P-3, Q-4, R-2, S-1
Web servers host HTML documents representing instruments, while remote panels allow users to interact directly with front panels from client computers. Network shared variables facilitate seamless data exchange between distributed applications across various networks, and SMTP program modules are designed to send email notifications programmatically. This mapping correctly aligns each specific network feature with its functional purpose.

21. (A) ActiveX / Component Object Model (COM)
ActiveX and Component Object Model technologies enable different software applications to interact and share data programmatically. Within a virtual instrumentation system, this communication standard allows the program to open external applications like Microsoft Excel, manipulate worksheets, and populate cells with acquired measurement data. This integration streamlines automated report generation and data post-processing.

22. (D) The Integral term
In a proportional-integral-derivative control loop, the integral action is primarily responsible for eliminating steady-state error. It accomplishes this by continuously accumulating the system error over time and adjusting the controller output accordingly. Even if the current error is small, the accumulated sum continues to drive the system until the offset is completely resolved.

23. (B) To identify contrasting boundaries for measurement and inspection
Edge detection algorithms are fundamental tools in machine vision used to identify significant variations in pixel intensity within an image. These sharp changes typically correspond to physical boundaries, shapes, or object contours. By highlighting these edges, the software can perform accurate dimensional measurements, locate specific parts, and conduct automated quality inspections.

24. (C) The calculated path of positions, speeds, and timing
In automated motion control systems, a motion trajectory represents the calculated path that defines the exact positions, velocities, accelerations, and timings of a moving component. The motion controller uses this mathematical profile to command the motor driver, ensuring smooth acceleration, precise target positioning, and controlled deceleration during operation to prevent mechanical stress.

25. (D) The shift from hardware-centric boxes to software-defined architectures
The evolution of measurement systems toward virtual instrumentation is characterized by a fundamental shift from rigid, hardware-centric instruments to flexible, software-defined architectures. Traditional instruments relied on fixed physical dials and analog circuits designed by manufacturers. Virtual systems leverage powerful personal computers and modular hardware, allowing engineers to customize instrument functions entirely through software.

NODIA

26. (A) A mechanical pneumatic pump
A computer-based measurement system relies on specific electronic and computational elements to function. Transducers convert physical phenomena into electrical signals, signal conditioning modules prepare those signals for digitization, and data acquisition interfaces convert analog values into digital data. Mechanical components, such as pneumatic pumps, do not perform measurement, digitization, or signal processing tasks.

27. (B) It executes when data arrives at all of its required input terminals
Under the graphical data-flow programming paradigm, execution is dictated by data availability rather than sequential line-by-line commands. A node on the block diagram remains inactive until every one of its required input terminals receives data. Once this condition is met, the node executes and outputs data downstream, guiding the natural execution path.

28. (B) To display a dynamically updating temperature graph
Front panel objects are strictly divided into controls and indicators. Controls function as system inputs, allowing users to supply parameters like setpoints or toggle states. Conversely, indicators act as system outputs, displaying data generated by the block diagram. Using a control to display an actively updating temperature graph is incorrect, as that requires an indicator.

29. (A) Visual identification of the VI's purpose on a block diagram
Editing the icon of a sub-VI provides a clear, pictorial representation of the module's underlying function on the block diagram. This visual representation allows developers to quickly identify what each sub-VI does within the overall program flow without opening its internal code. This practice significantly improves code readability and simplifies main application debugging.

30. (B) I and III
A while loop always executes at least once because its conditional terminal is evaluated at the end of the first iteration. Shift registers are designed to pass values from the end of one loop iteration to the start of the next. However, a For loop can execute zero times if its count terminal receives zero.

31. (D) Case Structure
A case structure functions as the graphical equivalent of text-based decision-making statements such as "if-then-else" or "switch-case". It contains multiple sub-diagrams, or cases, but executes only one specific case depending on the value wired to its selector terminal. This structure allows the program to branch and execute different logic paths during runtime.

32. (C) To group a Boolean status, a numeric code, and a text source
An error cluster is a standard complex data type designed to manage error distribution throughout a virtual instrument. It contains three primary components: a Boolean status indicating if an error occurred, a numeric error code, and a text string specifying the error source. This package ensures safe execution and simplifies debugging across functions.

33. (B) Because the data points are sampled at irregular time intervals
While standard waveform graphs plot data points that are sampled at strictly uniform time intervals, an XY graph is specifically designed to plot data points sampled at irregular intervals. The XY graph accepts pairs of coordinate points, allowing it to accurately represent mathematical relationships, parametric curves, and measurements that do not rely on a constant timebase.

34. (D) It executes text-based mathematical scripts alongside graphical code
A MathScript node enables developers to incorporate text-based mathematical scripts directly into a graphical program. This node is highly useful for executing complex equations, signal processing algorithms, and matrix calculations written in a standard syntax. It combines the ease of text-based math modeling with the visual power of a graphical interface.

35. (A) Race conditions and unpredictable data overwriting may occur
Using local variables excessively and indiscriminately can easily lead to race conditions within a parallel programming environment. Because multiple independent loops may attempt to read and write to the same variable simultaneously, the exact timing of these operations becomes non-deterministic. This conflict results in unpredictable data overwriting, memory latency issues, and difficult-to-trace software bugs.

36. (C) String manipulation functions
Parsing structured textual data retrieved from a basic text file requires string manipulation functions. These built-in utilities allow developers to split strings, search for specific patterns, format numerical values, and isolate relevant segments within the raw text data.

Downloaded from www.pdf.tube

This processing converts raw, unorganized text streams into structured numeric or Boolean formats used by the system.

37. (A) They store human-readable parameters to initialize the application
Configuration files, commonly using the INI extension, are simple, human-readable text files designed to store initialization settings and parameters for a virtual instrument. They allow operators to adjust operational variables, such as default file directories, serial port addresses, or calibration offsets, without modifying the underlying source code of the main application.

38. (D) It is highly immune to voltage drops and electrical noise
A 4-20mA current loop is widely preferred in long-distance industrial instrumentation because of its exceptional immunity to electrical noise and voltage drops. Since the signal is represented by current rather than voltage, resistive line drops along long cables do not alter the measured value, ensuring precise data transmission over extreme distances in harsh factory environments.

39. (B) IEEE 488 (GPIB)
The IEEE 488 standard, commonly known as General Purpose Interface Bus, defines a robust, 8-bit parallel multi-master bus engineered for connecting laboratory instrumentation. It allows a central controller to communicate with and coordinate multiple listening and talking devices simultaneously, facilitating high-speed, reliable automated data collection and instrument control within test and measurement environments.

40. (B) II and III
Virtual Instrument Software Architecture commands are designed to be independent of specific hardware manufacturers, which significantly enhances code portability. This architecture allows developers to switch between different physical communication interfaces without rewriting their applications. Therefore, claiming that commands depend on specific manufacturers and reduce system portability is incorrect.

41. (D) The resolution of the ADC
The resolution of an analog-to-digital converter determines the smallest change in analog voltage that the system can detect. Typically expressed in bits, this parameter dictates the number of discrete steps used to represent the analog range. A higher bit resolution divides the voltage range into smaller steps, enabling the system to capture finer signal variations.

42. (A) It is ruggedized and runs a deterministic OS for standalone use
An embedded controller is specifically engineered for rugged industrial environments and standalone operation, distinguishing it from standard desktop computers. It typically features a compact, fanless design and runs a deterministic real-time operating system. This configuration guarantees precise timing and reliability for critical monitoring, data logging, and closed-loop control tasks in demanding conditions.

NODIA

43. (B) To act as a communication bridge between varying automation systems
In industrial automation, OLE for Process Control serves as a crucial communication bridge between disparate hardware systems and software applications. It provides a standardized interface that allows virtual instruments, supervisory systems, and database systems to exchange data with various programmable logic controllers and industrial devices, regardless of their native proprietary communication protocols.

44. (B) SMTP VIs
Simple Mail Transfer Protocol virtual instruments enable an application to programmatically send automated email alerts, status reports, or diagnostic notifications over the internet. This feature allows remote monitoring systems to immediately inform operators or engineers of critical alarm states, system updates, or process data without requiring their physical presence at the control station.

45. (A) Using COM technology to share data with external applications
ActiveX communication relies on Component Object Model technology to facilitate seamless data sharing and control between separate software applications. Within a virtual instrument, this protocol allows developers to embed external controls, access functionalities of other Windows-based programs, and automate tasks like document editing or database querying directly from the graphical user interface.

(C) The derivative action dynamically calculates and fully neutralizes system delay
(D) The targeted loop setpoint value fluctuates and changes automatically in memory

2019
265. What fundamental machine vision algorithm is utilized to count distinct contiguous blobs in a binary image?
(A) Color inversion
(B) Particle analysis / Blob analysis
(C) Blurring
(D) Spatial calibration

2010
266. Which type of motor feedback device provides absolute position information even after a power cycle?
(A) Incremental encoder
(B) Absolute encoder
(C) Standard DC tachometer
(D) Limit switch

2022
267. What is the fundamental operational difference between an indicator and a control in a VI?
(A) Controls provide user input to the diagram; indicators display output data
(B) Indicators provide user input to the diagram; controls display output data
(C) Controls process numeric data streams; indicators display boolean LED states
(D) Indicators execute code continuously; controls execute only once per cycle

2023
268. Which tool is primarily used to adjust the physical size of an object on the front panel?
(A) The Probe tool
(B) The Wiring tool
(C) The Positioning tool
(D) The Labeling tool

2015
269. What execution advantage does graphical data-flow programming offer natively for multi-core processors?
(A) It streamlines program architecture by completely avoiding multi-threaded execution environments
(B) It serializes all execution by forcing independent loops to run on a single processing core
(C) It relies on developers manually writing complex C++ compiler pragmas to activate multithreading
(D) It supports parallel execution by automatically assigning independent branches to separate cores

2010
270. Which of the following is considered the best practice for documenting the purpose of a Sub-VI?
(A) Leaving the default, generic icon entirely unchanged in the diagram
(B) Documenting all specifications by writing user manuals on the panel
(C) Designing a descriptive icon and adding context help in the properties
(D) Saving the finalized sub-VI file under a completely randomized name

****

Click Here to Buy book on Amazon

56. (C) Unbundle elements from the cluster
To apply mathematical functions to individual components within a cluster, a developer must first use an unbundle or unbundle-by-name function. Because a cluster groups diverse data types into a single complex variable, raw mathematical nodes cannot process the cluster as a whole. Extracting the individual elements makes them available for standard calculations.

57. (D) It plots blocks of data at once, erasing past traces
A waveform chart is designed to append individual data points to an ongoing historical buffer, making it ideal for monitoring slowly changing processes. It does not erase past traces to plot blocks of data all at once; that behavior is characteristic of a waveform graph, which displays completed datasets rather than continuous incremental updates.

58. (A) By using a Call Library Function Node to link a DLL
A Call Library Function Node allows developers to integrate compiled C/C++ algorithms directly into a graphical virtual instrument without rewriting the code. By linking to an external dynamic link library, this node enables the program to pass parameters to the compiled function, execute the high-speed algorithm, and retrieve the processed results back into the block diagram.

59. (B) They can lead to race conditions due to a lack of synchronization
Relying heavily on global variables to exchange data between independent loops can easily lead to race conditions because they lack native synchronization mechanisms. If one loop writes data at the same moment another reads it, the resulting values become unpredictable. This behavior degrades reliability, introducing intermittent glitches that are difficult to isolate during development.

60. (A) Both A and R are true and R is the correct explanation of A.
Reading binary files is significantly faster than reading text files because binary formats store data in the computer's native memory representation. This raw storage eliminates the processor overhead required to convert text strings back into numerical values. Consequently, binary files maximize data throughput and reduce CPU utilization during high-speed, continuous data logging operations.

61. (A) Database Connectivity Toolkits
Database connectivity toolkits provide dedicated functions and components designed to interface a virtual instrument with standard SQL databases. These tools allow the application to programmatically establish connections, execute structured queries, insert newly acquired measurements, and retrieve historical data records. This integration supports robust data storage and retrieval within enterprise automation systems.

62. (C) RS-232C - Resistant to ground potentials over long runs
The RS-232C serial communication standard relies on single-ended signaling, referencing all transmission signals to a single common ground. This electronic configuration makes the interface highly susceptible to ground potential differences and electromagnetic interference over long cable runs. Therefore, claiming that RS-232C is resistant to ground potentials over long runs is incorrect.

63. (D) It provides software functions that abstract raw SCPI commands
An instrument driver acts as an essential software interface that abstracts complex SCPI commands into high-level graphical function blocks. Instead of manually writing raw text commands to configure an instrument, developers can use these driver functions to execute tasks like initialization, calibration, or measurements, ensuring efficient program development and hardware portability.

64. (C) Interchangeable Virtual Instruments
The acronym IVI stands for Interchangeable Virtual Instruments. This standard defines a unified architecture for instrument drivers, allowing developers to swap test instruments from different manufacturers without modifying the main test software application. It categorizes common instruments like digital multimeters and oscilloscopes into generic classes, ensuring broad driver compatibility and system longevity.

NODIA

65. (B) 2.44 mV
For a data acquisition module configured with a twelve-bit analog-to-digital converter over a voltage range of zero to ten volts, the total voltage

46. (C) Increasing Derivative time
If a closed-loop system exhibits severe oscillations in response to a step input, adjusting the derivative parameter is the standard method for adding damping. Increasing the derivative time allows the controller to predict future error trends based on its current rate of change. This action counteracts rapid fluctuations, stabilizes the system, and quickly reduces overshoot.

47. (D) Thresholding
Thresholding is a fundamental image processing operation in machine vision that converts a grayscale image into a binary, black-and-white representation. It evaluates the intensity of each pixel against a designated threshold value, assigning pixels above the threshold to white and those below to black. This process isolates target objects from their backgrounds for inspection.

48. (C) An optical encoder or resolver
An optical encoder or resolver serves as the primary feedback device in a closed-loop motion control system. It monitors the actual physical position of the motor shaft and generates corresponding electrical signals for the controller. The controller compares this feedback to the target position, dynamically correcting errors to ensure highly accurate motion profiles.

49. (B) It integrates hardware, data analysis, and a graphical interface
Virtual instrumentation is distinguished from standard computer programming by its unified integration of physical measurement hardware, sophisticated data analysis algorithms, and dynamic graphical user interfaces. While traditional programming languages focus heavily on general software logic, virtual instruments are engineered specifically to acquire raw real-world data, process it, and present immediate visual feedback to operators.

50. (B) I, II and IV
In virtual instrument systems, the computer serves as the central processing unit for data analysis, while signal conditioning modules ensure electrical signals match safe levels for measurement. These platforms seamlessly integrate hardware control and visualization. However, data acquisition hardware translates physical signals into digital data rather than the reverse, and virtual instruments can generate analog outputs.

51. (A) The flow of data through the connecting wires
In a graphical programming environment, the flow of execution is strictly governed by the movement of data through the connecting wires on the block diagram. A node cannot begin running until data has traveled along all incoming wires to its input terminals. This data-flow paradigm completely replaces the traditional sequential instruction pointer used in text languages.

52. (C) Wiring tool
The wiring tool on the system palette is specifically designed to establish electrical and logical data paths between different nodes on the block diagram. By selecting this tool, developers can connect terminals of controls, indicators, functions, and sub-VIs, defining the precise routing of data that dictates the execution order under the data-flow paradigm.

53. (A) A function's parameter list
The connector pane of a virtual instrument serves as the graphical equivalent of a function's parameter list or signature in text-based programming. It defines the specific input and output terminals of a VI, allowing it to receive data from and return results to a calling parent program. This configuration enables seamless integration of sub-VIs.

54. (D) Auto-Indexing
Auto-indexing is a built-in feature that allows a For loop to automatically determine its total iteration count based on the number of elements in an incoming array. When enabled, the loop processes one array element per iteration, eliminating the need to manually program array boundaries or wire the loop's count terminal, simplifying code structure.

55. (B) Event Structure
An event structure is specifically engineered to handle asynchronous user interface interactions, such as clicking a button or changing a numerical slider. When a registered user action occurs on the front panel, the structure detects it and executes the corresponding block of code, ensuring highly responsive and resource-efficient user interfaces without continuous CPU polling.

Downloaded from www.pdf.tube

and amplifying microvolt signals up to standard voltage levels, ensuring high measurement accuracy and computer system safety.

75. (B) The node will not execute until the third input receives its data
Under the data-flow execution model, a node cannot begin running if any of its required inputs are missing data. If a function block expects three distinct inputs and only receives two, it halts execution and waits indefinitely. This design ensures that calculations only occur when all necessary datasets are fully available, preventing logical programming errors.

76. (B) An LED bulb
An LED bulb is a classic example of an indicator on a virtual instrument's front panel. Indicators display output information received from the program, such as execution status, errors, or threshold crossings. In contrast, controls like toggle switches, sliders, and numeric inputs allow the operator to input parameters and manage the program flow.

77. (A) The Sub-VI's connector pane terminals must be wired
To pass data from a main program into a sub-VI, the developer must wire the appropriate terminals on the sub-VI's connector pane. This pane acts as the functional interface of the sub-VI, defining its input and output paths. Without wiring these connections on the parent block diagram, data cannot enter the modular sub-program during execution.

78. (C) It stores data from a previous loop run for the next iteration
A feedback node is a programming structure that stores data from a completed loop iteration and makes it available for the subsequent run. This behavior matches the function of a shift register but features a more compact graphical footprint on the block diagram. It is commonly used for implementing digital filters and recursive algorithms.

79. (D) The loop executes a frame if no user interaction occurs in time
Configuring a timeout event inside an event structure located in a while loop ensures the program remains active even when no user interactions occur. If the designated timeout period expires without a front panel action, the structure triggers the timeout case. This mechanism allows the loop to periodically execute tasks like sensor polling or background logging.

80. (A) I and III
Arrays are structured collections of identical data types and can easily be configured with multiple dimensions to represent matrices. Conversely, clusters can combine different data types and support nested hierarchies containing other clusters. Therefore, the statements asserting that arrays are multi-dimensional and require identical data types are correct, while the nesting restriction is false.

81. (B) The graph plots the entire array at once, replacing previous plots
A waveform graph is designed to receive an entire array of data points and plot it all at once, replacing the previous trace displayed on the screen. Unlike a chart, which accepts single values sequentially and maintains an ongoing history, the graph is optimized for displaying completed blocks of measurements acquired over a specific interval.

82. (D) Formula Node
A formula node is the most efficient programming construct for evaluating complex logic trees and mathematical algorithms containing multiple variables. It uses text-based syntax, allowing developers to write complicated math equations and conditional structures inside a single block. This text implementation drastically reduces diagram clutter and enhances the execution performance of computational routines.

83. (A) Network latency can introduce unpredictable delays in variable updates
When utilizing shared variables across a wide area network, developers must account for network latency. Transmission delays can introduce unpredictable timing gaps between when a variable is written on one system and when it is read on another. This jitter can disrupt synchronization in distributed applications, requiring careful design of error handling and timing.

NODIA

84. (C) Open → Write → Close
The standard file input and output sequence necessary to prevent file corruption is open, write, and close. First, the program obtains a file

104. (C) Combining variables into a single logical cluster structure
Combining separate variables into a single, organized structure requires using a bundle or bundle-by-name function. These functions gather individual elements of varying data types, such as integers, Booleans, and strings, and package them into a single cluster wire. This organization simplifies block diagram wiring and helps maintain clean program interfaces.

105. (D) XY Graph
An XY graph is the appropriate visualization tool when plotting two independent arrays with potentially irregular spacing. While standard waveform graphs assume a constant time interval between sequential data points, the XY graph plots coordinate pairs. This capability makes it ideal for representing mathematical relationships, orbital trajectories, and non-time-based sensor measurements.

106. (A) It permits direct reuse of .m scripts without rewiring
A major benefit of using a MathScript node over standard graphical functions is its support for direct reuse of existing text-based script files. This capability allows developers to import complex algorithms, mathematical models, and data processing routines without manually rebuilding them as graphical blocks. It saves development time and ensures numerical consistency.

107. (B) Queues or Notifiers
Using queues or notifiers is the most robust method for safely transferring data between parallel loops. These structures provide native synchronization mechanisms that regulate data flow, ensuring that the receiving loop processes data in the correct order. This design prevents race conditions and data loss, unlike unsynchronized local or global variables.

108. (B) Because continuous file I/O operations introduce high latency
Opening and closing a file inside a high-speed data acquisition loop is bad practice because these file operations require operating system system calls. These interactions introduce significant latency and jitter, which can cause the data acquisition buffer to overflow and lead to lost data. Opening files before the loop begins resolves this issue.

109. (A) To load configuration parameters like file paths and thresholds
Parsing an INI configuration file at the start of execution allows an application to load operational parameters such as default file paths, calibration offsets, and alarm thresholds. This practice enables developers to change system behavior without modifying the graphical source code, enhancing software flexibility, usability, and maintenance in industrial environments.

110. (A) Both A and R are true and R is the correct explanation of A.
A 4-20mA current loop can easily detect a completely broken wire in the transmission line. Since a broken wire interrupts the circuit, the current drops to zero milliamperes. This state is easily distinguished from a four milliampere signal, which represents the zero-scale measurement value, allowing the monitoring system to quickly identify physical wiring faults.

111. (D) IEEE 488 (GPIB)
The IEEE 488 parallel interfacing standard, also known as GPIB, utilizes a robust twenty-four-pin connector and relies on a designated controller-in-charge to coordinate bus traffic. This protocol manages communication between talkers, listeners, and controllers on the shared bus, ensuring highly reliable, automated command transmission and data collection in test environments.

112. (C) It requires memorizing register addresses for all devices
The Virtual Instrument Software Architecture provides a unified application programming interface that abstracts communication with physical instruments over different connections. It eliminates the need to memorize register addresses or configure low-level hardware registers directly. Therefore, claiming that using this architecture requires memorizing register addresses for all devices is incorrect.

113. (B) Aliasing, generating false low frequency components
In analog-to-digital conversion, sampling a signal at a rate lower than the Nyquist threshold causes aliasing. This phenomenon folds high-frequency noise and signals back into the measurement band, generating false low-frequency components that did not exist in the original analog signal. Aliasing permanently distorts the digitized

Click Here to Buy book on Flipkart

94. (C) The system may become unstable and oscillate severely
In a closed-loop system simulation, setting the proportional gain of a PID controller excessively high can lead to severe instability and oscillation. While a larger gain increases the response speed of the controller, it also amplifies the corrective action, causing the system to overshoot its target setpoint repeatedly and generate continuous, uncontrolled fluctuations.

95. (A) Spatial filtering (e.g., Gaussian blur)
Spatial filtering techniques, such as a Gaussian blur, are widely used in machine vision to remove high-frequency noise from captured images. These operations smooth the image by averaging the intensity values of neighboring pixels, which reduces speckle noise and pixel fluctuations. This preparation improves the performance of subsequent steps like edge detection and contour analysis.

96. (C) To ensure smooth speed and acceleration to a target position
Trajectory generation in motion control systems involves calculating a precise motion profile to guide a motor smoothly to its target position. It defines how velocity and acceleration change over time, preventing abrupt movements that can cause mechanical wear, vibrations, or overshoot. This profile ensures precise, controlled movement across the mechanical axis.

97. (B) The virtual oscilloscope leverages a generic PC and modular DAQ for functionality defined by software
The fundamental difference between a traditional oscilloscope and a virtual oscilloscope lies in where their operational logic resides. Traditional oscilloscopes use fixed, manufacturer-defined hardware circuits and buttons. In contrast, virtual oscilloscopes utilize standard personal computers and modular data acquisition hardware, allowing the core measurement, processing, and display functions to be entirely customized through software.

98. (D) The Signal Conditioning module
The signal conditioning module is responsible for isolating high-voltage signals from the sensitive computer bus. In data acquisition systems, electrical isolation prevents high-voltage spikes, ground loops, and electrical noise from damaging the computer processor and motherboard. This isolation ensures operator safety and maintains high signal integrity during high-voltage measurements.

99. (A) Independent nodes can automatically execute in parallel
The data-flow paradigm is highly advantageous for multi-core processors because it naturally supports parallel execution. Since nodes execute as soon as their required inputs receive data, any independent, unlinked paths on the block diagram can run simultaneously. The underlying compiler automatically maps these parallel tasks to separate CPU cores without manual coding.

100. (A) I, II and V
The front panel contains graphical controls and indicators, while the block diagram houses the source code. The run button is located on the toolbar, not the tool palette. Therefore, statements claiming the front panel contains code, the block diagram contains user controls, and the run button is on the palette are incorrect.

101. (A) The terminal name is bolded
In the system environment's Context Help window, a terminal name appearing in bold text indicates that the corresponding connection is strictly required for the sub-VI to execute. If a required input terminal is left unwired on the block diagram, the compiler generates a syntax error and prevents the main program from running.

102. (D) A While Loop executes based on a conditional terminal; a For Loop executes a predetermined number of times
The primary difference between a while loop and a for loop is how they control their execution iterations. A while loop runs continuously until a Boolean condition wired to its terminal changes state, making it ideal for event monitoring. In contrast, a for loop executes a predetermined number of times defined by its count terminal.

103. (B) Two cases (True and False)
When a case structure is connected to a Boolean control, it must contain at least two cases, true and false, to compile successfully. This requirement ensures that the program has an execution path for both possible binary inputs, preventing run-time errors and guaranteeing logical completeness under the data-flow programming model.

Downloaded from www.pdf.tube

142. (C) It is highly platform-dependent, limiting software execution exclusively to Windows environments
ActiveX is a legacy software framework developed by Microsoft that relies heavily on the Component Object Model. Because it is deeply integrated into the Windows operating system architecture, it is fundamentally non-portable. This platform dependency prevents cross-platform deployment, meaning applications utilizing ActiveX components cannot execute natively on alternative operating systems such as Linux, macOS, or real-time targets.

143. (B) Set point − Process Variable
In feedback control loops, the error signal is the fundamental metric used to drive control actions. Mathematically, the error is computed continuously by subtracting the current measured process variable from the desired target setpoint. This difference dictates the magnitude and direction of corrective outputs generated by the controller to bring the system back into steady alignment.

144. (D) The camera sensor's pixel grid and the optical lens magnification
Spatial resolution in machine vision systems determines the smallest physical feature that can be distinguished in an acquired image. This characteristic is strictly defined by hardware factors, specifically the total number of pixels on the camera sensor grid and the magnification ratio of the chosen optical lens. These physical parameters dictate the real-world area represented by each pixel.

145. (A) It provides an absolute physical reference point to calibrate motor coordinates
Motion control systems often utilize incremental encoders, which only track relative movement and lose absolute position data upon power loss. To establish a reliable coordinate system, a home switch is installed at a fixed physical location. During initialization, the motor moves until it triggers this sensor, setting a precise, repeatable zero reference point for all subsequent motion paths.

146. (C) Vacuum tube amplification
Virtual instrumentation leverages modern digital technologies to build flexible, software-centric measurement solutions. Its fundamental concepts include software-defined logic, modular hardware interfaces, digital signal processing, and highly interactive graphical user interfaces. Vacuum tube amplification, by contrast, is a legacy analog hardware component that is entirely irrelevant to the core principles of computer-based, software-driven modern instrumentation.

NODIA

147. (A) Control
In graphical programming environments, user interface elements on the front panel are classified as either controls or indicators. Controls function specifically as input mechanisms, allowing operators to enter numeric values, toggle boolean states, or input text. This data is then supplied directly to the block diagram nodes to dictate the execution and logical flow of the program.

148. (D) Data-flow
The data-flow programming paradigm dictates that a block diagram node cannot execute until it receives all required input data tokens. Once execution completes, the node produces output tokens, which travel along wires to subsequent nodes. This structured propagation of data, rather than a sequential list of text commands, determines the execution order of graphical programs natively.

149. (B) The wire is drawn noticeably thicker than a scalar data wire
Graphical block diagrams use visual coding on wires to represent different data types and structures. While scalar numeric wires are thin, solid lines, the diagram represents a one-dimensional array of the same data type with a noticeably thicker solid wire. This visual distinction helps developers quickly identify array data pathways and verify correct terminal wiring without probing.

150. (A) I, II and III
Modular programming structures simplify application development by breaking complex code into smaller subprograms. Using subprograms reduces block diagram clutter, allows repeated execution from multiple locations, and requires a defined connector pane to map inputs and outputs. Designing programs hierarchically actually simplifies debugging by isolating functional blocks, while editing an icon does not change underlying mathematical code.

data, making accurate signal reconstruction impossible.

114. (D) RTOS guarantees a strict maximum bound on response time (latency)
The fundamental difference between a standard operating system and a real-time operating system is task determinism. A real-time operating system guarantees a strict, predictable maximum bound on task response times. This determinism ensures that critical operations, such as industrial safety shutdowns or control loop updates, execute reliably within precise deadlines without interruption.

115. (A) To provide process visualization and control inputs
In a SCADA system, the primary role of the human-machine interface is to provide real-time process visualization and accept control inputs from operators. It displays interactive graphics representing industrial machinery, sensor measurements, and alarm states. This interface allows personnel to monitor complex factory operations and input new parameters safely.

116. (C) Installing the full VI source code on the client computer
Publishing a virtual instrument using a remote panel configuration eliminates the need to install the full source code on the client computer. The client machine only needs a standard web browser or light runtime engine to view and interact with the live front panel, simplifying software deployment and protecting proprietary application logic.

117. (A) It allows dynamic formatting and editing of the report during runtime
An inherent advantage of using ActiveX over standard file writing for report generation is the ability to perform dynamic formatting during runtime. Instead of writing flat text files, ActiveX allows the program to control Microsoft Office applications directly. This interface enables real-time adjustments to table structures, font styles, and chart layouts as data is processed.

118. (D) A string formatting function for text file headers
Developing a closed-loop control system simulation requires a mathematical model of the plant, a PID controller algorithm, and a feedback path to calculate errors. While formatting text strings for file headers is useful for saving logs, it is not relevant to the core control loop calculation, feedback execution, or dynamic system simulation.

119. (B) The specific area of an image isolated for processing and analysis
In machine vision applications, a region of interest refers to a specific coordinate area within a captured image isolated for processing. By limiting analysis to this targeted area, the software avoids wasting processing power on irrelevant background pixels. This optimization significantly increases execution speeds and improves measurement accuracy for automated inspection tasks.

120. (A) P-2, Q-3, R-4, S-1
Technical Data Management Streaming files are optimized for storing high-speed waveform data with metadata, while standard text files are ideal for slow, human-readable logs. INI files serve to save application startup configuration settings, and relational databases provide efficient cross-referencing for massive historical datasets. This mapping aligns each data storage mechanism with its typical use case.

121. (D) The motor's steps per revolution
In automated motion control, the fundamental parameter that defines the physical step distance of a stepper motor is the motor's steps per revolution. This physical characteristic dictates how many electrical pulses the controller must send to rotate the motor shaft by a specific angle, ensuring precise open-loop position control.

122. (A) Using fixed, vendor-defined physical instrument faceplates
Virtual instrumentation directly bypasses the limitations of rigid, vendor-defined physical instrument faceplates. Traditional instruments feature fixed physical buttons, dials, and screens that cannot be altered. By shifting control and visualization functions to a personal computer, virtual instrumentation allows developers to build customized user interfaces that display only the necessary controls and indicators.

123. (B) The quality of the sensors and DAQ conditioning hardware
The overall measurement accuracy of a virtual instrumentation system is primarily determined by the quality of its physical sensors and data

Click Here to Buy book on Amazon

reference from the operating system. Next, the data is written to the file stream. Finally, the close function releases the reference, ensuring all buffered data is fully saved to disk.

85. (A) An integrated hierarchy of files, groups, and channels
Technical Data Management Streaming files are self-describing due to their integrated three-tier hierarchy consisting of files, groups, and channels. The file level contains global metadata, the group level categorizes data, and the channel level contains raw measurements. This structured organization allows developers to save descriptive names and properties directly alongside binary datasets for easy archival.

86. (D) RS-485
The RS-485 serial communication standard uses balanced, differential signaling to transmit data across two distinct wires. The receiver measures the difference in voltage between these lines, which effectively cancels out common-mode noise and ground potential differences. This design provides robust noise immunity, supporting reliable communications over long distances in industrial settings.

87. (B) Talker-only
Within an IEEE 488 bus architecture, a device configured as a talker-only can transmit data onto the shared bus but cannot receive commands or parameters from other controllers. This operating mode is typically used for basic instrumentation, such as older digital multimeters, which only need to output active measurements without external programming during a test.

88. (C) Swapping hardware from different vendors without altering test software
Interchangeable Virtual Instruments provide a standardized driver architecture designed to decouple test software from physical hardware. This design allows engineers to swap instruments from different manufacturers without rewriting their application code. By utilizing unified class drivers, the software remains compatible with different hardware models, reducing long-term maintenance costs and protecting testing investments.

89. (D) Triggering
In data acquisition systems, triggering refers to the process of synchronizing the start of a measurement sweep with an external electrical pulse or condition. This technique ensures that data collection begins at a precise moment, such as when a voltage threshold is crossed, allowing developers to capture transient events with accurate timing.

90. (A) I and III
Real-time operating systems prioritize task determinism over overall processing throughput. They guarantee that critical operations, such as closed-loop motor control or safety monitoring, always execute within strict, predefined time limits. However, these specialized operating systems are not immune to hardware failures and differ significantly from standard desktop environments like Windows.

91. (B) To translate proprietary hardware protocols to standard client formats
In an OPC architecture, the primary role of the OPC server is to act as a translation layer. It converts proprietary, device-specific communication protocols from diverse hardware manufacturers into a standardized format. This translation allows different client applications, such as virtual instruments and HMI systems, to easily read and write data to industrial machinery.

92. (B) SMTP delivery times are non-deterministic and subject to network delays
Using standard email via SMTP for critical real-time industrial alarms is highly limited because email delivery times are inherently non-deterministic. Transmission speeds depend heavily on network traffic, server routing queues, and internet connectivity, introducing unpredictable delays. Therefore, SMTP cannot guarantee the immediate response times required to manage dangerous conditions and prevent equipment damage.

93. (A) An ActiveX Client
When a virtual instrument programmatically opens Microsoft Word, inserts data, and formats a report, it acts as an ActiveX client. In this architecture, Microsoft Word operates as the ActiveX server, exposing its internal functions and properties to the client application. This relationship allows the virtual instrument to control the document generation process.

NODIA

achieved using Match Regular Expression functions. These built-in string utilities parse the text stream, identify patterns that match the specified search criteria, and extract the target substring. This output can then be converted into numeric formats for further analysis.

134. (D) They are inefficient for high-speed continuous waveform data
A significant limitation of INI configuration files is their inefficiency for storing high-speed, continuous measurement data. Because INI files are structured text formats designed for human-readable parameters, saving massive, rapidly updating numeric arrays within them requires extensive text conversion. This overhead introduces high latency, making binary or TDMS formats much better suited for streaming.

135. (B) It establishes the speed of data transmission in bits per second
In RS-232 serial communication, the baud rate parameter establishes the speed of data transmission in bits per second. This setting determines the rate of electrical transitions on the communication line, and both the sending and receiving devices must be configured with the exact same baud rate to interpret transmitted serial data packets correctly.

136. (A) It uses shielded cables, secure stackable connectors, and hardware handshaking
The IEEE 488 GPIB standard ensures robustness in demanding laboratory environments through its physical layer design. It incorporates heavily shielded cabling to minimize electromagnetic interference, rugged stackable connectors to prevent accidental disconnections, and a dedicated hardware handshaking protocol. This combination guarantees reliable, noise-immune parallel data communication between various scientific instruments and controllers.

137. (B) Interchangeable Virtual Instruments (IVI) driver architectures
Interchangeable Virtual Instruments driver architectures provide a highly standardized software interface for controlling test equipment. By abstracting the specific hardware commands into generic class drivers, this technology enables developers to write code that remains functional across different instrument brands and models. This architecture minimizes code modifications when replacing hardware interfaces like USB or GPIB in measurement applications.

138. (B) scales small input signals to span a larger portion of the ADC range, enhancing measurement precision
In data acquisition, increasing the amplification gain of the signal conditioning stage matches weak analog signals to the full dynamic input range of the analog-to-digital converter. This scaling process utilizes more discrete quantization levels, which decreases quantization noise and significantly improves overall measurement resolution. Consequently, small input voltage variations are resolved with much greater precision.

139. (A) The VI must target the specific RTOS and hardware architecture of the controller
Compiling a virtual instrument to run on an embedded hardware controller requires targeting the specific real-time operating system and processor architecture of the physical target. This configuration is essential because the compilation process converts the graphical source code into optimized machine instructions tailored directly to the hardware. Without this precise targeting, the compiled executable cannot run properly.

140. (A) I and III
Supervisory Control and Data Acquisition systems are highly distributed architectures designed for large-scale, widespread industrial processes, rather than small-scale single rooms. Additionally, virtual instruments are fully capable of being integrated seamlessly into these setups to handle monitoring and supervisory control. Therefore, assertions describing them as single-room exclusive or impossible to integrate with virtual instrumentation are incorrect.

141. (D) Unauthorized remote clients can control physical hardware if access lists are misconfigured
Implementing a web server for remote panel access introduces severe security risks if accessibility is left open. When access control lists and client permissions are improperly configured, unauthorized network clients can gain active command over the user interface. This critical vulnerability allows remote users to manipulate physical machinery or actuators, potentially causing severe hardware damage or safety hazards.

Downloaded from www.pdf.tube

acquisition conditioning hardware. While software manages data analysis and display, it cannot correct errors introduced by low-quality transducers, poor analog-to-digital conversion, or unshielded cables susceptible to electrical noise and distortion.

124. (B) Branching wires can duplicate data in memory if not optimized
In data-flow programming, a key memory management consideration is that branching wires can duplicate data in memory if not optimized. When a wire splits to send the same dataset to multiple independent nodes, the compiler may create separate copies of the data, which can increase memory usage when handling large arrays.

125. (A) User controls
A virtual instrument's block diagram contains the graphical source code, including terminals, function nodes, sub-VIs, and connecting wires. Physical user controls, such as buttons, knobs, and slides, reside exclusively on the front panel user interface. Although the block diagram contains corresponding control terminals, the actual user controls are not placed on the diagram.

126. (C) It promotes code reuse, simplifies debugging, and reduces clutter
Creating a modular program structure through sub-VIs is a primary best practice because it promotes code reuse, simplifies debugging, and reduces block diagram clutter. By packaging specific functional operations into individual sub-VI blocks, developers can test modules independently and easily integrate them across different applications, improving development efficiency and software reliability.

127. (D) It evaluates a Boolean to control loop execution
The conditional terminal of a while loop evaluates a wired Boolean value at the end of each iteration to determine whether to continue or stop execution. This terminal can be configured to stop on true or continue on true, allowing developers to safely exit loops based on user inputs, error occurrences, or measurement conditions.

128. (C) Frames execute sequentially from left to right
A flat sequence structure forces sequential execution on a block diagram by executing its frames from left to right. A frame cannot begin running until all operations in the preceding frame have fully completed. This structure allows developers to precisely control execution timing and order, bypassing the default parallel behavior of the data-flow model.

129. (B) Bundling the two arrays into a Cluster
To plot a dataset on an XY graph, a developer must combine a 1D array of X values and a 1D array of Y values into a single cluster structure. The XY graph is designed to accept this clustered data format, allowing it to correctly map coordinate pairs and represent relationships between two independent variables.

130. (A) I and II
A waveform graph receives an entire array of data and plots it all at once, replacing previous traces. A waveform chart is typically placed inside a loop to append single points sequentially and maintain a history. An XY graph can plot irregularly spaced data and does not require strictly uniform intervals to function.

131. (A) Call Library Function Node
The Call Library Function Node is specifically designed to integrate compiled external C/C++ code into a virtual instrument. This node links directly to dynamic link libraries, enabling the program to pass parameters, execute compiled functions, and retrieve processed outputs within the block diagram, supporting high-speed processing and reuse of legacy software assets.

NODIA

132. (C) Race conditions occur, making the output value unpredictable
Using local variables to write to the same front panel indicator from two parallel loops simultaneously introduces race conditions. Because the loops execute independently and without synchronization, the exact order of write operations is non-deterministic, making the displayed value unpredictable. It is critical to use synchronized structures like queues to manage parallel data.

133. (A) Using Match Regular Expression functions
Searching a large, unstructured text string for a specific numeric value is most effectively

151. (D) It accumulates values from all iterations and outputs them as a consolidated array
When an auto-indexed output tunnel is enabled on a loop structure, it automatically handles array accumulation. Throughout loop execution, the tunnel collects individual scalar values generated during each iteration in a sequential buffer. Upon completion of the loop, these collected elements are exported as a consolidated, ordered one-dimensional array, matching the total iteration count.

152. (A) Case Structure
A case structure is specifically designed to handle conditional execution branching within graphical code. By connecting a numeric variable to the selector terminal, the developer can define distinct subdiagrams for different values. When the input matches a specific value, only the corresponding case executes, while different code runs for any other configured values or the default case.

153. (B) To extract specific elements using their logical labels instead of order
Clusters group heterogeneous data elements into a single wire, but accessing individual components requires extraction. Utilizing the unbundle by name function allows developers to retrieve specific variables directly by referencing their logical labels. This approach is highly robust because it prevents errors associated with manual element order tracking, ensuring code stability when cluster layouts are modified later.

154. (B) Waveform Graph
Visualizing the frequency spectrum of a signal requires displaying a complete, pre-calculated dataset of frequency versus amplitude. A waveform graph is the most appropriate front panel indicator for this purpose because it accepts an array of completed data and plots the entire dataset at once. This behavior matches the batch nature of fast Fourier transform calculations.

155. (A) It requires all variables to be explicitly declared with their data types inside the node
A formula node allows developers to execute text-based mathematical equations directly within a graphical program. However, it imposes strict syntax rules, requiring every input, output, and temporary variable to be explicitly declared with its data type, similar to standard C-style programming. Failing to properly define these variables inside the node boundaries results in compilation and execution failures.

156. (C) It allows properties and methods of the front panel object to be accessed programmatically
Control references provide a powerful abstraction for programmatic user interface manipulation. Unlike local variables, which primarily read or write the data values of controls, a reference provides direct access to the underlying object. This allows developers to dynamically modify properties like visibility, color, or disabled states, and invoke complex methods during execution from anywhere in the application.

157. (D) Scan From String or String To Number conversion standard functions
Instrument data acquired via serial interfaces typically arrives as raw ASCII character streams. To manipulate this information mathematically, standard string parsing functions must convert the character representations into actual numeric data types. Functions such as scan from string search the incoming stream using specified formatting codes to extract and output valid numeric variables for processing.

158. (C) The metadata is integrated directly within the same file as the raw data
The Technical Data Management Streaming format is highly optimized for measurement systems. A key design strength is that it embeds descriptive metadata directly within the binary file structure alongside the raw waveforms. This self-describing layout ensures that essential data properties, such as sensor names, scales, and acquisition timestamps, remain permanently bound to the binary data when transferred.

159. (B) A 0mA value indicates a fault or broken wire, enabling fail-safe detection
The four-to-twenty milliamp current loop is a highly robust industrial communication standard. By establishing a live zero level of four milliamps for the minimum scale value, the physical loop can easily distinguish between zero-scale measurements and hardware issues. If the loop current drops to zero milliamps, the system immediately recognizes a broken wire or transmitter fault.

Click Here to Buy book on Flipkart

160. (A) Both A and R are true and R is the correct explanation of A.
Standard Commands for Programmable Instruments define a highly uniform command syntax and hierarchical structure that instrument manufacturers widely adopt. This universal standardization abstracts hardware differences, permitting the same control code to communicate effectively with similar instruments from different brands. Consequently, software applications achieve high hardware independence because the underlying command structures are standardized across the test industry.

161. (A) A high-level hardware abstraction layer
Virtual Instrument Software Architecture serves as a critical hardware abstraction layer. It provides a highly standardized application programming interface that unifies communications across diverse physical interfaces. By presenting a consistent set of function calls, it insulates the development application from low-level bus differences, allowing developers to control serial, GPIB, USB, and Ethernet hardware using identical code structures.

162. (C) Sampling Rate
In data acquisition systems, the sampling rate is the primary specification that defines performance limits. It determines the maximum frequency at which the analog-to-digital converter can continuously capture discrete measurements of a continuous physical signal. According to sampling theory, this rate must be sufficiently high to avoid signal aliasing and ensure accurate signal reconstruction.

163. (A) The timing deviation of a supposedly periodic deterministic task
Real-time systems require precise determinism to ensure that scheduled control loops run at predictable intervals. In this context, jitter represents the unwanted timing variation or deviation between the actual execution time of a periodic task and its scheduled theoretical execution interval. Minimizing jitter is critical for maintaining stability and control precision in high-speed hardware applications.

164. (D) By providing standard software interfaces between field devices and SCADA systems
Open Platform Communications simplifies manufacturing automation by bridging the gap between proprietary hardware protocols and higher-level software. It serves as a universal translator, providing standard interfaces that allow supervisory systems to communicate seamlessly with diverse programmable logic controllers and field sensors. This interoperability eliminates the need for developers to write custom, hardware-specific drivers.

NODIA

165. (B) HTTP/TCP
Web servers built into graphical programming environments enable remote monitoring of user interfaces using standard network protocols. Under the hood, these servers utilize the hypertext transfer protocol running over transmission control protocol connections to stream data packets. This network configuration allows remote clients to render the front panel in compatible web browsers or lightweight client software.

166. (C) A reusable component from another application operating inside the VI
ActiveX controls embedded within a front panel function as reusable software modules developed in external programs. By integrating these objects directly into the graphical interface, developers can access specialized capabilities, such as advanced data grids, media players, or document viewers. This interoperability allows the host application to reuse pre-built Windows components without recreating complex display logic.

167. (D) The accumulated steady-state offset error over time
Proportional-integral-derivative controllers use three distinct terms to regulate systems. While the proportional action responds to current error, the integral term focuses on past performance. It integrates the error over time, calculating the total accumulated deviation. By applying a control response proportional to this historical accumulation, the integral action effectively eliminates any persistent steady-state offset errors.

168. (A) Pattern Matching
Pattern matching is a powerful computer vision technique utilized to locate specific features within an acquired image. The algorithm operates by comparing regions of the active image against a pre-configured reference template, seeking areas with high spatial correlation. This technique is highly effective for identifying components,

determining part orientation, and performing automated inspection tasks in industrial environments.

169. (B) Coordinating multiple axes to follow a complex, curved geometric path
Contouring is an advanced motion control technique critical for multi-axis automation. Rather than simply moving independent axes to discrete locations sequentially, contouring coordinates the position, velocity, and acceleration of multiple motors simultaneously. This synchronization ensures that the tool head or mechanical actuator traces a continuous, complex, and highly accurate curved path in multi-dimensional space.

170. (B) P-3, Q-4, R-2, S-1
Graphical programming concepts translate directly to common constructs in textual languages. Wires on a block diagram function as variables to pass data between nodes. Auto-indexing on a loop corresponds directly to iterating through array elements sequentially. A subprogram node acts as a standard function call, while a case structure represents conditional execution blocks like switch statements.

171. (A) It runs the software that performs analysis, user interface, and system control
In virtual instrumentation architectures, the personal computer serves as the central processing unit. Unlike traditional instruments with fixed hardware configurations, the computer runs the flexible software application that defines the instrument's entire functionality. It executes signal analysis algorithms, displays the graphical user interface, manages file input and output, and issues control commands to modular hardware.

172. (C) Directly driving heavy mechanical loads without intermediate motor amplifiers
Virtual instruments are designed for measurement, signal analysis, software interface execution, and control signal generation. However, the modular interface boards and computer ports output only low-power electronic signals. They cannot supply the high electrical current required to drive heavy mechanical loads directly. Intermediate motor amplifiers and power drives are always necessary to bridge this physical gap.

173. (D) When all nodes inside the loop have finished execution and produced output data
The data-flow paradigm governs execution order entirely through data availability. Inside a loop structure, an individual iteration cannot complete until every node contained within its boundaries has finished processing and produced its respective outputs. Once all data pathways are resolved for that frame, the loop can evaluate its conditional terminal and decide to terminate or repeat.

174. (C) Labeling / Text tool
Modifying text values, such as the labels or captions on front panel objects, requires the appropriate tool. The labeling or text tool is specifically designed to select, insert, and edit characters within text boxes, control labels, and free-form block diagram annotations. Using this tool allows developers to easily customize the visible button text during user interface design.

175. (B) The calling VI will become broken and refuse to run
When designing a subprogram, developers can configure specific input terminals as required. If a programmer leaves any required terminal unwired when placing the subprogram on a main block diagram, the compiler cannot guarantee complete data flow. Consequently, the main program immediately breaks, the execution arrow turns broken, and the code refuses to run until wired.

NODIA

176. (D) While Loop
A while loop requires a conditional terminal to decide whether execution should continue or stop. This terminal evaluates a boolean value, which must be wired to a control, comparison function, or error cluster. If left unwired, the compiler cannot determine the termination condition, causing the program to break and preventing execution until the wire is connected.

177. (A) The event is ignored unless the structure is explicitly configured to handle it
Event structures handle user interface interactions and system cues asynchronously. If an event occurs on the front panel but has not been registered or configured within the event structure cases, the execution engine simply discards or ignores the notification. The program continues its normal operation without

a virtual instrument is often accomplished using Component Object Model interfaces. Specifically, ActiveX automation allows a developer to launch, configure, and manipulate applications like Microsoft Word or Excel. This interface enables the program to dynamically insert measurement data, format tables, and generate reports automatically.

216. (A) Settling Time
In feedback control loop design, settling time is a critical performance parameter. It represents the total elapsed time required for the controlled process variable to enter and remain within a specified error band around the desired setpoint following a change. Minimizing settling time indicates a well-tuned system that responds rapidly to setpoint adjustments without excessive oscillation.

217. (B) To expand and link adjacent bright pixel regions within a binary thresholded image
Morphological dilation is a fundamental image processing operation used in binary machine vision. The dilation operator expands the boundaries of bright pixel regions within an image. This expansion is highly useful for filling in small interior holes, linking closely spaced adjacent structures, and smoothing out rough outer edges of thresholded objects prior to performing automated particle analysis.

218. (B) The pre-calculated profile curve of target velocity plotted against time
Automated motion controllers must move mechanical loads smoothly to prevent physical wear and system instability. To achieve this, the controller calculates a trajectory profile before initiating motion. This profile represents the target velocity plotted against time, defining precise acceleration, constant velocity, and deceleration phases that the motor must follow to reach its destination safely.

219. (A) It relies entirely on analog calculation methods
The historical evolution of virtual instrumentation is characterized by a fundamental transition from legacy analog hardware instruments to modern digital systems. Virtual instrumentation relies heavily on digital computers and high-speed processors to analyze and display data. Characterizing this evolution as relying entirely on analog calculation methods is incorrect, as digital computing is its primary foundation.

220. (A) P-2, Q-3, R-4, S-1
The development environment includes several integrated components, each serving a unique function. The front panel acts as the user interface, containing controls and indicators. The block diagram houses the graphical source code and logical wiring. The context help window provides documentation for hovered items, while the probe tool displays active wire values during execution.

221. (D) The node bypasses execution and passes the incoming error directly to its output port
Error handling in graphical programming relies on error clusters passed between nodes sequentially. When an error is present in the incoming cluster, standard nodes bypass their primary execution logic entirely. Instead of performing their configured operations, they pass the incoming error information directly to their output terminals, allowing subsequent nodes to ignore operations and propagate the error.

222. (C) A State Machine architecture linking a While Loop and a multi-frame Case Structure
Developing complex, multi-state control programs requires a highly flexible architecture. A state machine provides this design by combining a continuous while loop with a multi-frame case structure. The current state is maintained by a shift register and used to select the next executing case, allowing the program to transition dynamically between initialization, acquisition, and shutdown.

223. (B) To abstract system complexity and enable modular, readable, and reusable code
Hierarchical program design is highly emphasized in virtual instrumentation architectures. By dividing a complex block diagram into smaller, self-contained subprograms, developers can abstract system complexity. This modular design makes the code significantly more readable, simplifies debugging and testing, and enables code reuse across multiple projects, accelerating development and maintaining code quality.

224. (D) A For Loop configured with Auto-Indexing enabled
Processing array datasets sequentially is a very common task in measurement software. A for

Downloaded from www.pdf.tube

187. (A) Sequentially switching a single ADC to sample multiple input channels
In data acquisition hardware, multiplexing is a highly cost-effective technique used to monitor multiple analog signals. Rather than dedicating a separate analog-to-digital converter to each channel, a multiplexer rapidly switches a single converter among several input pathways sequentially. This allows a multi-channel board to sample numerous inputs while using only one core digitizing component.

188. (C) A high-resolution hardware timer with priority interrupt scheduling
Real-time operating systems must guarantee that critical control tasks execute precisely on schedule. Achieving this strict level of determinism requires specialized hardware components, specifically a high-resolution hardware timer coupled with priority-based interrupt scheduling. This combination allows the system scheduler to preempt lower-priority processes immediately, ensuring execution timing remains highly predictable and free from operating system lag.

189. (D) OPC
Open Platform Communications is the standard industry protocol for connecting supervisory software to physical controllers. It provides a highly uniform, tag-based communication interface that abstracts the proprietary communication languages of different manufacturers. This standardization allows SCADA nodes to easily read and write data points on programmable logic controllers across the factory network.

190. (A) II, III, IV, I
Deploying a remote panel requires a sequential server and client configuration. First, the developer must enable the web server within the development environment settings. Next, access control lists must be configured to define authorized client IP addresses. After publishing the specific user interface using the publishing tool, the client can access the panel via a web browser.

191. (B) An ActiveX Object Reference
Automating external Microsoft Excel operations from a graphical program relies on Component Object Model technologies. Inside the block diagram, an ActiveX object reference is utilized to represent specific elements of the Excel application structure, such as workbooks or sheets. This reference acts as a programmatic pointer, enabling the application to set properties and invoke methods on that target.

192. (D) It operates without utilizing sensor feedback to adjust its control output
Control architectures are broadly categorized as either open-loop or closed-loop. An open-loop control system is characterized by its complete lack of feedback mechanisms. The controller determines and applies its output command based solely on a pre-configured mathematical model or simple timer, without monitoring sensor data to verify if the desired process variable has actually been achieved.

193. (A) To capture and buffer continuous image frames in computer memory at high speed
High-speed vision applications generate massive amounts of visual data that must be captured without dropping frames. A frame grabber is a specialized hardware component designed to interface with industrial cameras. Its primary function is to capture, digitize, and transfer incoming video streams directly to the host computer's system memory using highly efficient direct memory access transfers.

194. (C) To damp system oscillations by predicting future trend lines of the error
In feedback position control systems, the derivative action analyzes the rate of change of the calculated error signal. By anticipating future error trends, the derivative term generates a damping effect on the control output. This damping is critical for suppressing excessive system overshoot and preventing severe mechanical oscillations, helping the system stabilize smoothly at its target position.

195. (A) A system combining computers, modular hardware, and flexible software for custom measurement and control
Virtual instrumentation represents a modern approach to test and measurement systems. It integrates powerful personal computers, flexible modular hardware interfaces, and customizable software development tools. By transferring the definition of instrument functionality from fixed hardware dials to computer software, this methodology enables engineers to easily build, update, and scale custom measurement and control solutions.

NODIA

253. (D) Local / Global Variables
Graphical programming relies fundamentally on the data-flow paradigm, where data travels along visible wires. However, complex multi-window architectures often require sharing data across disjointed code sections. Utilizing local or global variables bypasses strict data-flow rules by allowing direct memory access. While convenient, this approach introduces risks of race conditions if multiple threads access variables simultaneously.

254. (C) Spreadsheet String to Array, configured with the correct delimiter
Text-based spreadsheet files represent tabular data using characters like commas or tabs to separate columns. Reading this data into an array requires a conversion function. The spreadsheet string to array function parses the raw text stream using a specified delimiter, converting the string characters into a structured multi-dimensional array of numeric values for analysis.

255. (B) It organizes data into hierarchical groups and channels with searchable metadata
Standard text logging formats suffer from a lack of organization when managing complex test configurations. The Technical Data Management Streaming format resolves this by using a structured, three-level hierarchy comprising file, group, and channel levels. This architecture allows developers to append detailed metadata at each level, enabling rapid searching and sorting of historical test runs.

256. (D) The 4-20mA loop offers a live zero (4mA) to reliably detect broken wire faults
The primary advantage of a four-to-twenty milliamp current loop over a zero-to-twenty milliamp configuration is its fault detection capability. Because a valid minimum signal is represented by four milliamps rather than zero, the system has a live zero. If the current drops to zero milliamps, the receiver immediately identifies a broken cable or transmitter failure.

257. (A) IEEE 488.1
The General Purpose Interface Bus standard is defined by two complementary specifications. The IEEE 488.1 standard explicitly governs the physical layer, defining the mechanical connectors, cabling shielding requirements, pin configurations, and electrical signal levels. This hardware foundation ensures that compliant test equipment from different manufacturers can interface together physically without signal compatibility issues.

258. (C) It handles serial, GPIB, USB, and Ethernet instruments through a unified API
Virtual Instrument Software Architecture provides a highly standardized communication framework. Its primary strength is presenting a unified application programming interface for instrument control. By abstracting the low-level communication protocols, it allows developers to write consistent code that interfaces with serial, GPIB, USB, and Ethernet devices using identical functions, simplifying multi-instrument system design.

259. (A) The analog input range / programmable gain amplifier
In data acquisition hardware, the maximum voltage that can be safely and accurately measured is defined by the analog input range. This range is determined by the input attenuation circuits and the programmable gain amplifier. Exceeding these physical limits saturates the measurement or can potentially damage the internal analog-to-digital converter.

260. (D) Executing closed-loop millisecond turbine control
General-purpose operating systems are highly efficient for non-critical tasks like report generation or user interface rendering. However, high-speed closed-loop control of machinery, such as industrial turbines, requires strict execution deadlines. For these critical applications, a deterministic real-time operating system is essential to guarantee that the control loop executes exactly on schedule without millisecond-level delays.

261. (B) It requests and consumes data from an OPC Server regardless of underlying hardware
In industrial automation networks, Open Platform Communications simplifies data exchange. Within this architecture, the client application functions as a data consumer. It requests and monitors variables from the OPC server, which acts as a translator for physical controllers. This design isolates the client software from low-level communication protocols, enabling seamless data integration across different brands.

Click Here to Buy book on Amazon

and write to the same data tag seamlessly, without requiring manual TCP socket programming.

206. (C) Set File Position (seek to end)
Reading data from the end of a very large text file can be highly inefficient if the entire file must be parsed first. To optimize performance, developers utilize file position functions to dynamically move the file read pointer. Setting the file position to seek from the end allows the program to read the latest records immediately, saving memory.

207. (B) It uses a separate hierarchical index of properties apart from raw data blocks
The Technical Data Management Streaming format achieves high-speed performance and rapid historical data queries through its unique internal design. It separates raw measurement data blocks from a distinct hierarchical index file containing the structured properties. This dual-file architecture allows database query engines to search metadata and locate specific records rapidly without reading massive binary signal arrays.

208. (D) 4-20mA loop
While many common communication standards utilize voltage variations to transmit information, industrial environments often introduce high electrical noise that corrupts voltage signals. The four-to-twenty milliamp current loop standard transmits analog signals using current instead. This design is highly resistant to voltage drops over long cable lengths, making it the industry standard for reliable remote sensor monitoring.

209. (B) 15
The IEEE 488 standard defines specific physical and electrical limits for the General Purpose Interface Bus. To maintain signal integrity and ensure reliable parallel handshaking across the shared lines, the bus architecture typically limits the total number of connected instruments. A single standard GPIB controller can interface with up to fifteen devices on one physical bus.

210. (A) Both A and R are true and R is the correct explanation of A.
Instrument drivers are critical for accelerating virtual instrumentation development. They achieve this by abstracting the low-level, complex command strings into intuitive, modular graphical functions. Instead of manually drafting raw text commands, developers can drop pre-built blocks to configure and read instruments. This abstraction drastically reduces implementation time and minimizes programming errors during development.

211. (A) Pre-triggering with a circular buffer
Capturing transient waveforms or fault signals often requires analyzing the events that immediately led up to the trigger. Data acquisition systems achieve this through pre-triggering. This technique utilizes a circular buffer in memory that continuously records incoming data. When the trigger event occurs, the system preserves the buffered historical data, providing a complete record before the trigger.

NODIA

212. (D) NI CompactRIO (cRIO)
High-performance industrial systems require highly reliable and customizable control architectures. CompactRIO hardware platforms deliver this capability by combining an embedded processor running a real-time operating system with a reconfigurable field-programmable gate array. This dual-processing architecture provides both deterministic software execution and high-speed, hardware-level custom timing and control logic on a single rugged chassis.

213. (B) Telemetry / Data Acquisition
In supervisory control architectures, monitoring a geographically distributed network of sensors relies on telemetry. Telemetry represents the process of measuring physical parameters at remote, unattended locations and transmitting that data back to a central host. This automated data acquisition process allows the supervisory software to display real-time system status and make operational control decisions.

214. (C) Request Control permission must be granted by the host
While web servers allow remote clients to view active user interfaces in real time, interactive control is restricted to prevent command conflicts. For a remote client to actively manipulate controls on a remote panel, they must explicitly obtain control permission from the host. This security handshake ensures that only one operator controls the hardware at once.

215. (D) ActiveX Automation
Integrating and controlling external office software applications programmatically from

interruption, as the structure only responds to explicitly configured event cases.

178. (C) Arrays enable programmatic iteration, sorting, and vector operations on datasets
Storing data in arrays offers major advantages over individual scalar variables. Arrays group homogeneous data elements into a single organized structure, enabling developers to perform programmatic iterations, sorting algorithms, and efficient vector operations. This consolidation simplifies data passing on the block diagram and allows loops to process massive datasets dynamically with highly compact, readable code.

179. (A) Intensity Graph
An intensity graph is a specialized visualization component designed for multi-dimensional data representation. It accepts a two-dimensional array of numeric values and maps each value to a corresponding color defined by a color ramp. This mapping effectively produces a two-dimensional visual grid, making it highly suitable for displaying thermal profiles, matrix data, or localized sensor maps.

180. (B) Place the node → Select DLL path and configure parameters → Wire the inputs and outputs → Run the VI
Integrating a dynamic-link library function requires a systematic development process using the call library function node. The developer must first place the node on the block diagram and specify the path to the library file. Next, the function parameters and data types are configured. After wiring the inputs and outputs, the program can execute and call the library.

181. (B) Queue
Passing data between independent loops running at different speeds introduces the risk of race conditions and data loss. To mitigate this, a queue mechanism implements a first-in, first-out data buffer. Queues ensure that every data packet produced is stored temporarily until consumed, decoupling the producer and consumer loops and preventing data overwrites or missed updates.

182. (C) Threshold Image
Generating formatted text files from numeric data relies on specific file I/O and string conversion functions. Developers utilize functions to convert arrays to spreadsheet strings, open or create files on disk, and write text strings to those files. By contrast, thresholding is an image processing operation used to segment pixel data, making it completely irrelevant to writing spreadsheet text files.

183. (D) .tdms
The Technical Data Management Streaming format, identified by its specific file extension, is engineered for high-performance measurement applications. It is a binary file type optimized for writing high-speed data streams while maintaining a structured, hierarchical layout. This self-describing format integrates metadata directly into the file, facilitating fast data searches and cross-platform analysis without separate configuration files.

184. (A) To provide basic error detection during data transmission
Serial communication protocols transmit data sequentially over long distances, which can occasionally introduce electrical noise and transmission errors. Parity bits provide a simple, cost-effective error-checking mechanism. By appending a parity bit to each transmitted character, the receiving hardware can count the number of high bits and detect if a single-bit corruption occurred during the transmission process.

185. (B) IEEE 488.2 / SCPI
The IEEE 488.2 and Standard Commands for Programmable Instruments specifications provide a highly structured, common syntax for instrument control. This framework defines universal query commands, such as the identification request command, which all compliant benchtop instruments must recognize and respond to. This standardization ensures that control software can easily verify connected instrument types regardless of the manufacturer.

186. (B) Plug-and-play Instrument Driver VIs
Communicating with external benchtop instruments can be complex when relying on low-level command strings. Plug-and-play instrument drivers represent the highest level of software abstraction for this task. They wrap complex SCPI commands into pre-configured graphical functions. This allows developers to initialize, configure, read, and close instruments using high-level blocks, dramatically simplifying application development.

Downloaded from www.pdf.tube

loop with auto-indexing enabled is the ideal structure for this operation. This configuration automatically extracts one element per iteration from the wired array and determines the loop count based on the array size, eliminating manual indexing and loop control.

225. (A) Case Structure
Conditional execution in graphical code is managed through selection structures. A case structure contains multiple subdiagrams, or cases, but only one executes during a given run. The choice of which case to run is determined dynamically by the value wired to its selector terminal, which supports boolean, numeric, string, or enumeration inputs.

226. (C) It reduces diagram wire clutter by combining multiple wires into a single trunk
When block diagrams require passing numerous related data points across multiple nodes, the layout can become highly cluttered. Bundling distinct data types into a single cluster acts as a virtual cable harness. This consolidation combines multiple individual wires into a single structural trunk, improving code readability and simplifying subprogram interfaces without altering execution speed.

227. (A) Waveform Chart
Displaying live, continuous data streams requires specialized front panel indicators. A waveform chart is designed specifically for real-time monitoring because it contains an internal buffer. As new data points are received, the chart automatically appends them to the display while scrolling older data off the screen, mimicking the operation of a physical paper strip chart.

228. (D) Achieving deterministic, microsecond-level real-time hardware control
MathScript nodes are highly effective for rapid prototyping, complex matrix calculations, and importing legacy text-based scripts. However, the text-parsing and execution engine introduces variable processing overhead. Consequently, MathScript nodes are not suitable for high-speed, microsecond-level real-time control, which requires the strict, low-overhead determinism of native graphical blocks or FPGA code.

229. (B) Local Variable
Normal data passing on a block diagram relies on physical wires to maintain data flow. However, certain user interface designs require updating controls programmatically without wires. A local variable provides this capability, allowing different parts of the block diagram to read or write directly to a specific front panel control or indicator in memory.

230. (C) Open File → Array to Spreadsheet String → Write to Text File → Close File
Writing array data to a text file requires a logical sequence of file operations. First, the application must open or create the target file on disk. Next, the numeric array is converted into a formatted spreadsheet string using a delimiter. The program then writes this string to the file and closes the file reference to free resources.

231. (D) They are highly inefficient for storing massive, high-speed sensor datasets
Standard initialization files are highly useful for storing basic configuration parameters, such as calibration offsets or IP addresses, in a human-readable text format. However, their reliance on plain-text parsing makes them highly inefficient for high-speed logging. Storing massive sensor datasets in this format causes substantial disk write delays and rapidly consumes storage space.

NODIA

232. (A) To suppress signal reflections at transmission line ends
High-speed serial communication over long distances, such as in RS-485 networks, is susceptible to transmission line effects. When electrical signals reach the end of an unterminated cable, they can reflect back and cause signal corruption. Installing a termination resistor matching the characteristic impedance of the cable suppresses these reflections, ensuring reliable communication.

233. (B) 8-bit parallel, byte-serial asynchronous transfer with handshaking lines
The General Purpose Interface Bus utilizes a robust communication protocol designed specifically for instrument control. It transmits data using an eight-bit parallel, byte-serial asynchronous architecture. To ensure data is received correctly before the next byte is sent, the bus incorporates three dedicated hardware handshaking lines, establishing a highly reliable transfer system over short physical distances.

234. (B) Specifying the hardware port and instrument the software communicates with
Communicating with instruments requires identifying their physical location to the driver software. Virtual Instrument Software Architecture resource names function as unique address strings. These strings explicitly define the communication interface type, such as serial or GPIB, and the specific hardware address or port, directing the software commands to the correct physical instrument.

235. (A) Maximum Sampling Rate
Capturing high-frequency analog signals requires data acquisition hardware that can sample at a sufficient speed. The maximum sampling rate is the primary specification that limits this capability. According to Nyquist theory, the hardware must sample at more than twice the highest frequency component of the signal to prevent aliasing and ensure accurate wave reconstruction.

236. (C) It ensures deterministic execution free of operating system background interruptions
Standard operating systems, such as Windows, prioritize user interface updates and background tasks, which can introduce unpredictable execution delays. For critical industrial control, an embedded controller running a real-time operating system is required. This configuration guarantees deterministic execution, ensuring that control loops run precisely on schedule without being interrupted by non-critical background processes.

237. (D) OLE DB / ODBC Database Connectivity
Integrating automated manufacturing applications with enterprise systems requires standard database interfaces. Virtual instruments achieve this using Object Linking and Embedding for Databases or Open Database Connectivity interfaces. These standard drivers allow the application to execute structured query language commands, enabling direct reading and writing of measurement and quality data to central IT databases.

238. (C) The local Run-Time Engine and a compatible web browser plugin
Viewing and interacting with a published remote panel does not require a full software development license on the client machine. Instead, the client PC only needs a compatible web browser equipped with the appropriate runtime plug-in, along with the local installation of the corresponding run-time engine. This allows the client to render the panel interface correctly.

239. (B) Property or Invoke Nodes wired to an Automation Refnum
Programmatic control of external Windows applications is typically managed via Component Object Model interfaces. Within a graphical block diagram, developers use an automation reference to point to the external application class. By wiring this reference to property or invoke nodes, the program can read or write properties and execute application-specific methods, automating reports seamlessly.

240. (A) I, II, III, IV
Executing a closed-loop control application requires a strict sequential process in each cycle. First, the program reads the current process variable from the analog input hardware. Next, the feedback error is calculated by subtracting this measurement from the setpoint. The PID algorithm then processes this error to determine and output the corrective command to the actuator.

241. (A) Pattern matching / Geometric matching
Locating circular components and determining their center coordinates is a common computer vision task. Geometric matching algorithms excel at this by analyzing shape boundaries rather than raw pixel intensities. By fitting a mathematical model to the edges of the circular object, the algorithm calculates the precise coordinates of its center, even under varying lighting conditions.

242. (C) It rotates in discrete angular steps triggered by digital pulse inputs
Stepper motors differ fundamentally from continuous DC motors in their design and control method. They consist of multiple electromagnetic coils arranged around a central rotor. By applying digital command pulses sequentially to these coils, the motor rotates in highly precise, discrete angular steps, allowing accurate open-loop position control without requiring complex feedback sensors.

Click Here to Buy book on Flipkart

243. (A) Measurement features can be modified in software without altering physical hardware
A key advantage of virtual instrumentation is its flexible, software-defined nature. Traditional hardware instruments have fixed functionality determined by their physical design. With virtual instruments, the signal processing, scaling, and user interface are defined in software, allowing developers to update, modify, or add measurement features easily without purchasing or altering the underlying physical hardware.

244. (D) A thick, resizable rectangular frame
Execution structures, such as loops, case structures, and sequences, are defined visually on the block diagram. Their physical boundary is represented by a thick, resizable rectangular frame. Any nodes or functions placed inside this frame are contained within that structure's execution domain, while wires passing through the borders are managed by interface tunnels.

245. (B) The physical RAM clock speed of the PC
The data-flow programming paradigm is a software execution model that governs how instructions run on the block diagram. It determines the parallel execution of independent loops, the sequential execution of wired nodes, and the propagation of variables through shift registers. The physical RAM clock speed of the host PC is a hardware-level specification, completely independent of software paradigms.

246. (C) The terminal is colored green
Graphical block diagrams rely on color-coded terminals and wires to signify different data types. A green terminal or wire indicates boolean data, which represents binary true or false states. This consistent visual mapping helps developers instantly verify data type compatibility between different function nodes, reducing wiring errors and accelerating the troubleshooting process during development.

247. (D) The Connector Pane
Creating a reusable sub-program requires defining its external interface. The connector pane of the subprogram is used to map specific front panel controls and indicators to its input and output terminals. This mapping defines how the subprogram appears on a calling block diagram, allowing other programs to wire data in and out of it.

248. (A) The shift register retains and uses the final value from the previous run
Shift registers preserve historical values across loop iterations. However, if a shift register is left uninitialized outside the loop boundary, its behavior depends on whether the application remains in memory. If the program is stopped and restarted, the uninitialized shift register retains and uses the final value from the previous run, which can lead to unpredictable calculations.

249. (B) A Case Structure wired to an error cluster status
Robust industrial applications must handle errors gracefully to prevent damage to machinery. To execute specific shutdown or cleanup code only when an error occurs, a case structure is utilized. By wiring the error cluster status directly to the selector terminal, the program executes the error-handling subdiagram when a fault is detected, ensuring a safe system state.

250. (B) Indexing passes one element per iteration; passing solid array processes the whole array at once
Tunnel configurations on a loop boundary dictate how array data is processed. Enabling indexing on the loop tunnel passes exactly one element per iteration sequentially, automatically setting the loop count. In contrast, passing a solid, non-indexed array transfers the entire dataset into the loop structure as a single object, allowing the nodes inside to process the whole array.

251. (A) Intensity Graph
Plotting three-dimensional datasets on a flat, two-dimensional screen requires creative visualization. An intensity graph achieves this by mapping the X and Y coordinates to the spatial grid of the display. The third dimension, Z, is represented by a color value mapped from a predefined scale. This representation is highly effective for displaying thermal profiles or spatial matrices.

252. (C) Call Library Function Node
Reusing pre-existing, custom-compiled C or C++ libraries within a graphical program is a common integration requirement. To execute functions from a dynamic-link library, developers utilize the call library function node. This node enables the program to load the DLL, configure the calling conventions, map data types to C-style parameters, and execute the compiled code natively.

Downloaded from www.pdf.tube

196. (D) The graphical front panel and signal analysis logic
Traditional instruments rely on physical knobs, displays, and internal analog circuits to perform tasks. In a virtual instrument, these components are replaced entirely by software. The graphical front panel, user controls, data displays, and mathematical signal processing algorithms are software-defined. This allows developers to change the instrument layout, scaling, and behavior without altering any physical hardware.

197. (B) The Run button on the toolbar is shown as a broken arrow
The graphical compiler continuously analyzes the block diagram for syntax and wiring errors during development. If the compiler detects a critical issue, such as an unwired required terminal or incompatible data types, it marks the program as non-executable. This status is visually indicated on the toolbar by the run button transforming into a broken arrow.

198. (C) Highlight Execution (the lightbulb button)
Debugging graphical programs requires specialized visual tools. Activating the execution highlighting feature, represented by a lightbulb icon on the toolbar, dramatically slows down the execution speed of the block diagram. This slow-motion mode allows developers to observe data bubbles traveling along wires in real time, making it simple to trace logic errors and verify program flow.

199. (D) The specific pattern selected for the Connector Pane
To use a program as a sub-module within another application, its inputs and outputs must be accessible. The connector pane of the subprogram defines the physical arrangement and total number of these connection terminals. Choosing a specific terminal pattern on the connector pane dictates how other programs wire data into and out of the sub-module.

200. (A) A Shift Register or Feedback Node
Standard block diagram wires do not retain historical data between loop iterations, as they only carry current data values. To pass a calculated value from one iteration of a loop to the subsequent iteration, developers must utilize a shift register or a feedback node. This mechanism buffers the data at the loop boundary, making it available next frame.

201. (B) Flat Sequence Structure
While the data-flow paradigm natively determines execution order based on data availability, certain operations require strict chronological ordering. A flat sequence structure forces this sequential execution by dividing code into distinct, ordered frames. The execution engine guarantees that the code within each frame runs and fully completes from left to right before the next frame is allowed to start.

202. (B) An array of 5 elements is created, matching the size of the smaller array
Performing arithmetic operations on arrays of differing lengths triggers a behavior known as polymorphic terminal alignment. When two arrays are wired into a function like addition, the execution engine pairs the elements by index. Because it cannot pair values beyond the length of the shorter array, the operation truncates, resulting in an output array matching the smaller size.

NODIA

203. (B) Waveform Graph
Displaying complete, pre-acquired datasets on a front panel requires a suitable graphing indicator. A waveform graph is ideal for this purpose because it receives an entire array of data points and plots the complete curve instantly. Additionally, this indicator natively supports interactive features such as zooming, panning, and cursor measurements, enhancing the operator's data analysis capabilities.

204. (C) Formula Node
Graphical code can become complex when implementing highly mathematical equations with numerous nested functions. To simplify these block diagrams, a formula node provides a text-based scripting window inside the graphical environment. This node allows developers to type standard algebraic expressions directly using C-style syntax, improving code readability and reducing the overall diagram footprint.

205. (D) Network-Published Shared Variable
Sharing data values across different computers on a network requires a dedicated communication protocol. A network-published shared variable is specifically engineered for this task, utilizing a built-in publish-subscribe engine. This architecture enables multiple applications running on separate physical machines to read

262. (C) SMTP (Simple Mail Transfer Protocol) Send functions
Industrial monitoring systems often require notifying operators of alarm conditions automatically. To send email alerts directly from a virtual instrument, developers utilize simple mail transfer protocol functions. These functions connect to a specified mail server, format the message headers with sender and recipient addresses, and transmit the alarm text packet over the network to the recipient.

263. (D) Open an Automation Reference to the Word class
Inter-application communication using Component Object Model technologies requires establishing a connection before executing commands. To control Microsoft Word from a graphical program, the developer must first open an automation reference to the Word class. This reference initializes the external server process, establishing the programmatic link required to modify documents using subsequent property and invoke nodes.

264. (A) The controller may over-correct, causing instability if not tuned for the delay
Process dead-time represents the delay between applying a control action and observing its effect on the sensor. If this dead-time significantly exceeds the loop execution time, a standard PID controller may continue to apply corrective outputs before previous actions are felt. This lag often leads to severe over-correction, resulting in system instability and continuous oscillation.

265. (B) Particle analysis / Blob analysis
Countless industrial machine vision inspections require identifying and counting discrete parts. After thresholding an image to separate targets from the background, a particle or blob analysis algorithm is executed. This process detects contiguous regions of pixels, counts the total number of independent objects, and calculates spatial parameters such as area, perimeter, and center of gravity.

266. (B) Absolute encoder
Motion control systems rely on feedback devices to track position. While incremental encoders only monitor relative changes and require a homing cycle upon power loss, absolute encoders utilize unique optical or magnetic patterns for each angular position. This design allows the absolute encoder to report the exact mechanical position immediately upon power-up, eliminating any need for homing.

267. (A) Controls provide user input to the diagram; indicators display output data
User interfaces in virtual instrumentation are constructed from two distinct types of objects. Controls function as input mechanisms, enabling operators to enter variables or toggle states to the block diagram. Indicators, conversely, act as output displays. They receive processed data from the diagram nodes and present it to the user through charts, numeric fields, or status LEDs.

268. (C) The Positioning tool
Designing an intuitive user interface requires arranging and resizing front panel elements. The positioning tool, represented by an arrow cursor, is specifically designed for these layout tasks. Using this tool, developers can select objects on the panel, drag them to new locations, and grab their resize handles to adjust their physical dimensions on the screen.

269. (D) It supports parallel execution by automatically assigning independent branches to separate cores
The data-flow programming paradigm offers major advantages when executing on modern multi-core processors. Because the compiler determines execution order through data availability rather than sequential commands, it easily identifies independent code paths. The execution engine automatically distributes these parallel branches across available CPU cores, enabling multi-threaded execution without requiring manual thread management by the developer.

270. (C) Designing a descriptive icon and adding context help in the properties
Documenting subprograms is a critical practice for maintaining large development projects. Best practices dictate customizing the default icon with clear, descriptive graphics that represent the module's function. Additionally, developers should write detailed documentation within the sub-VI properties. This information is displayed in the context help window when hovering over the node, simplifying integration.

****

Click Here to Buy book on Amazon

CHAPTER 06
Analytical Instrumentation

2025

1. Which fundamental equation directly relates the electrode potential of an electrochemical cell to the concentration of electroactive species?
(A) Kohlrausch equation
(B) Nernst equation
(C) Ilkovic equation
(D) Beer-Lambert equation

2004

2. In a standard pH meter, what is the primary function of the automatic temperature compensation (ATC) system during measurement?
(A) To correct for changes in the buffer's ionic strength
(B) To adjust for the temperature-dependent hydration rate of the glass membrane
(C) To compensate for the temperature-dependent change in the Nernstian slope of the electrode
(D) To eliminate reference electrode polarization effects

2008

3. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Kohlrausch's law of independent migration of ions strictly applies only at infinite dilution.
Reason (R): At infinite dilution, interionic interactions are maximized in strong electrolytes.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

4. In a dissolved oxygen (DO) analyzer utilizing a Clark electrode, what is the primary function of the semipermeable membrane?
(A) To prevent electrolyte evaporation
(B) To catalyze the reduction of oxygen
(C) To maintain a constant temperature at the cathode
(D) To selectively allow the diffusion of oxygen while blocking interferences

2022

5. Which measuring principle is predominantly applied in specific ion analyzers designed for trace industrial silica detection?
(A) Colorimetric heteropoly blue method
(B) Flame emission spectrophotometry
(C) Amperometric titration
(D) Direct potentiometry with a glass electrode

2017

6. A deviation from the Beer-Lambert law at high concentrations is most commonly attributed to which phenomenon?
(A) Instrumental variations in the optical path length of the cuvette
(B) Uncontrolled fluctuations in the molar absorptivity coefficient
(C) Stray light leakage originating from the detection system components
(D) Electrostatic interactions between closely packed solute species

NODIA

2011

Match the UV-VIS spectrophotometry components in List I with their primary functions in List II.
List I: Components
P. Photomultiplier tube
Q. Deuterium lamp
R. Monochromator
S. Double-beam optics
List II: Primary Functions
1. Isolates specific wavelengths
2. Corrects for source intensity fluctuations
3. Provides continuous UV radiation
4. Amplifies low-intensity optical signals
(A) P-1, Q-3, R-2, S-4
(B) P-4, Q-3, R-1, S-2
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-4, R-1, S-2

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

2015

8. In Infrared (IR) spectroscopy, what is the primary mechanism of operation for a Nernst glower?
(A) Excitation of a hollow cathode lamp containing inert vapor
(B) Continuous electrical discharge in a high-vacuum gas tube
(C) Resistance heating of a rare-earth oxide ceramic rod
(D) Interferometric splitting of the primary infrared wave

2008

9. In Raman spectroscopy, the Stokes lines represent scattered photons that have:
(A) Higher energy than the incident photons
(B) Equivalent energy to the Rayleigh scattering
(C) Undergone complete absorption by the sample
(D) Lower energy than the incident photons

2023

10. Which zone of a standard analytical flame in Flame Emission Spectrophotometry typically provides the highest temperature for atomization?
(A) The pre-heating zone
(B) The primary combustion zone
(C) The interzonal region
(D) The secondary combustion zone

2018

11. Consider the following statements regarding atomic absorption spectrophotometry (AAS) interferences:
I. Chemical interference occurs when thermally stable compounds form.
II. Spectral interference requires the use of a hotter flame like nitrous oxide-acetylene.
III. Lanthanum is frequently added as a releasing agent to prevent phosphate interference with calcium.
Which of the above statement(s) is/are correct?
(A) I and III
(B) I, II and III
(C) II and III
(D) II only

2024

12. What distinguishes Inductively Coupled Plasma (ICP) from traditional flame excitation sources in Atomic Emission Spectrophotometry?
(A) ICP operates at significantly lower excitation temperatures to reduce spectral overlap
(B) ICP provides an inert argon environment that minimizes oxide formation
(C) ICP relies exclusively on hollow cathode lamps to generate excitation wavelengths
(D) ICP utilizes an integrated graphite furnace assembly for sample introduction

2021

13. Which equation is utilized to calculate the resolution (R) between two adjacent chromatographic peaks?
(A) $R = \dfrac{2\,(w_1 + w_2)}{t_{R2} - t_{R1}}$
(B) $R = \dfrac{2\,(t_{R2} - t_{R1})}{w_1 + w_2}$
(C) $R = \dfrac{t_{R2} - t_{R1}}{2\,(w_1 + w_2)}$
(D) $R = \dfrac{w_1 + w_2}{2\,(t_{R2} - t_{R1})}$

2001

14. In Gas Chromatography (GC), the Electron Capture Detector (ECD) is most sensitive to which class of compounds?
(A) Volatile aliphatic hydrocarbons
(B) Non-reactive noble gases
(C) Halogenated organic compounds
(D) Saturated aliphatic alcohols

2021

15. Consider the following statements regarding HPLC columns and mobile phases:
I. In reverse-phase HPLC, the stationary phase is non-polar.
II. Isocratic elution employs a mobile phase whose composition changes continuously over time.
III. Normal-phase HPLC separates analytes based on partitioning into a highly polar stationary phase.
IV. Gradient elution effectively reduces the retention time of strongly retained compounds.
Which of the above statement(s) is/are INCORRECT?
(A) I and III
(B) II only
(C) I, III and IV
(D) II and IV

2009

16. Which of the following HPLC detectors is universally considered a bulk property detector?
(A) UV-Vis absorbance detector
(B) Fluorescence detector
(C) Refractive Index (RI) detector
(D) Evaporative Light Scattering Detector

Downloaded from www.pdf.tube

2008
72. Which instrumental technique measures the optical emission from excited atoms returning to the ground state?
(A) Atomic Emission Spectrophotometry
(B) X-ray Fluorescence Spectroscopy
(C) Atomic Absorption Spectrophotometry
(D) Nuclear Magnetic Resonance Spectroscopy

2024
73. Hollow cathode lamps used in AAS are specifically filled with:
(A) An inert gas like Neon or Argon at low pressure
(B) A highly reactive gas like Fluorine at high pressure
(C) Liquid mercury to ensure constant vaporization
(D) Pure oxygen to facilitate combustion

2023
74. Which process is primarily responsible for chemical interference in Atomic Absorption Spectrophotometry?
(A) Light scattering by solvent droplets
(B) Spectral overlap of emission lines from other elements
(C) Premature ionization of analyte atoms in an overly hot flame
(D) Chemical formation of refractory compounds resisting atomization

2008
75. Consider the following statements regarding Inductively Coupled Plasma (ICP) principles:
I. ICP operates using a radio frequency generator coupled to a quartz torch.
II. The argon gas in the torch is seeded with electrons via a Tesla coil spark.
III. ICP plasmas can reach core temperatures exceeding 6,000 K.
IV. ICP is strictly limited to single-element analysis.
V. The high temperature of the ICP virtually eliminates chemical interferences.
Which of the above statement(s) is/are correct?
(A) I, II, III and V
(B) I, III, IV and V
(C) II, III, IV and V
(D) I, II, IV and V

2006
76. In chromatography, the retention factor ($k\hat{a}\text{€}^{\text{TM}}$) or capacity factor is a measure of:
(A) The average linear velocity of the flowing mobile phase
(B) Relative time spent in stationary and mobile phases
(C) The cumulative number of theoretical plates inside a column
(D) The total physical length of the packed chromatographic column

2009
77. Which detector in Gas Chromatography requires hydrogen and air to maintain a small flame?
(A) Photoionization Detector (PID)
(B) Thermal Conductivity Detector (TCD)
(C) Flame Ionization Detector (FID)
(D) Electron Capture Detector (ECD)

NODIA

2008
78. In Normal-phase HPLC, a gradient elution method typically involves continuously changing the mobile phase from:
(A) Non-polar to more non-polar
(B) Non-polar to more polar
(C) Polar to more polar
(D) Polar to more non-polar

2023
79. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): In normal-phase HPLC, hexane is commonly used as a starting mobile phase.
Reason (R): Hexane strongly binds to the polar silica stationary phase, facilitating analyte separation.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014
80. The sensitivity of a UV-Vis detector in HPLC is highly dependent upon the:
(A) Viscosity of the mobile phase
(B) Chromophoric properties of the specific analytes
(C) Boiling point of the analytes
(D) Pressure exerted by the pump

2004
81. Chemical shift in NMR spectroscopy is defined as the resonant frequency of a nucleus relative to a standard, typically expressed in:
(A) Teslas (T)
(B) Hertz (Hz)
(C) Parts per million (ppm)

(C) Specialized Sodium Glass Electrode
(D) Dropping Mercury Working Electrode

2013
27. Determine the correct arrangement of steps for calibrating a pH meter, then select the matching option.
I. Adjust the slope using a pH 4.01 or 9.18 buffer.
II. Rinse the electrode with distilled water.
III. Submerge the electrode in a pH 7.00 buffer.
IV. Adjust the baseline asymmetry (zero point).
(A) III, IV, II, I
(B) II, III, IV, I
(C) II, I, III, IV
(D) III, II, I, IV

2005
28. The cell constant of a conductivity cell is mathematically defined as:
(A) The ratio of the specific conductance to the equivalent conductance
(B) The distance between electrodes divided by their cross-sectional area
(C) The cross-sectional area divided by the distance between electrodes
(D) The applied voltage divided by the measured current

2014
29. In a wheatstone bridge circuit applied to conductivity measurements, alternating current (AC) is used instead of direct current (DC) to prevent:
(A) Polarization at the electrodes
(B) Thermal degradation of the solvent
(C) Dielectric breakdown of the cell
(D) High frequency electrical noise

2018
30. In polarography, which equation mathematically describes the limiting diffusion current at a dropping mercury electrode?
(A) Nernst equation
(B) Ilkovic equation
(C) Kohlrausch equation
(D) Beer-Lambert equation

2019
31. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Sodium ion-selective electrodes are commonly constructed using a specialized aluminosilicate glass membrane.
Reason (R): Aluminosilicate glass membranes are entirely impervious to all monovalent cations except sodium.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2021
32. In photometric measurements, stray light invariably causes:
(A) Systematic positive deviations from Beer's Law at elevated concentrations
(B) Improved calibration linearity at high concentrations
(C) Negative deviations from Beer's Law at high concentrations
(D) An increase in the calculated molar absorptivity coefficient

2002
33. Which component of a single-beam UV-Vis spectrophotometer converts transmitted light into an electrical signal?
(A) Tungsten-halogen lamp
(B) Monochromator
(C) Cuvette
(D) Photodiode

2004
34. A Michelson interferometer in FTIR spectroscopy relies on which of the following moving components to generate an interferogram?
(A) A moving mirror altering the optical path length
(B) A mechanically chopped continuous radiation source
(C) A sweeping magnetic field focusing IR rays
(D) A rotating grating dispersing polychromatic light

2011
35. Match the Flame Emission Spectrophotometry parameters in List I with their descriptions in List II.
List I: Flame Emission Spectrophotometry Parameters
P. Premix burner
Q. Total consumption burner
R. Pre-heating zone
S. Interzonal region
List II: Descriptions
1. Highest concentration of free atoms for measurement

Click Here to Buy book on Flipkart

2019
54. In a Geiger-Muller (GM) counter, the phenomenon of "quenching" is essential to:
(A) Increase the energy resolution of the detected radiation
(B) Enhance the detection efficiency of low-energy alpha particles
(C) Lower the characteristic detector dead time to near zero
(D) Prevent a continuous electrical discharge

2006
55. Determine the correct order of events in the operation of a Scintillation counter (NaI crystal), then select the matching option.
I. Photoelectrons are multiplied in the photomultiplier tube.
II. Incident gamma radiation deposits energy in the crystal.
III. The crystal emits visible light photons.
IV. Light photons strike the photocathode, releasing photoelectrons.
(A) II, IV, III, I
(B) II, III, IV, I
(C) III, II, I, IV
(D) II, I, III, IV

2007
56. What distinguishes a Proportional counter from an Ionization chamber?
(A) It collects primary ions without any gas multiplication
(B) It applies sufficient voltage to cause secondary ionization (Townsend avalanche)
(C) It operates at a lower applied voltage
(D) It is completely insensitive to beta radiation

2025
57. Differential Scanning Calorimetry (DSC) primarily measures the:
(A) Change in sample mass as a function of temperature
(B) Difference in heat flow between a sample and a reference
(C) Volume expansion of the material
(D) Gases evolved during thermal decomposition

2011
58. An endothermic peak in a DSC curve of a polymer typically corresponds to:
(A) Melting
(B) Crystallization
(C) Oxidation
(D) Curing

2018
59. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The standard hydrogen electrode (SHE) is assigned a potential of exactly 0.00 V at all temperatures.
Reason (R): It acts as the universal reference for defining standard electrode potentials based on the H^+/H_2 redox couple.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

NODIA

2012
60. A glass electrode's sensitivity to pH relies on the formation of what specific layer on the glass surface?
(A) A dry crystalline silicate layer
(B) A hydrated gel layer
(C) An inert polymer coating
(D) A metallic silver precipitate

2008
61. Why is an alkaline error commonly observed when using a glass pH electrode at pH values above 12?
(A) The internal reference buffer undergoes neutralization
(B) The membrane becomes permeable exclusively to OH- ions.
(C) The glass membrane physically dissolves in strong bases.
(D) The electrode responds to high concentrations of alkali metal ions, particularly sodium.

2011
62. The electrical conductivity of an aqueous electrolyte solution generally:
(A) Decreases by about 2% per degree Celsius rise in temperature
(B) Remains completely constant regardless of temperature changes
(C) Increases by about 2% per degree Celsius rise in temperature
(D) Halves for every 10 °C increase in temperature due to ion pairing

2016
63. Match the polarographic concepts in List I with their definitions in List II.
List I: Polarographic Concepts
P. Half-wave potential

chromophore in the analyte
(B) Can detect any analyte less volatile than the mobile phase
(C) Measures the refractive index of the pure solvent
(D) Emits fluorescence only upon UV excitation

2021

45. In NMR spectroscopy, the splitting of a resonance signal into a multiplet is primarily caused by:
(A) The Larmor precessional decay
(B) Inhomogeneities in the external magnetic field
(C) Chemical shift anisotropy
(D) Spin-spin coupling with adjacent non-equivalent nuclei

2010

46. Which mass analyzer employs four parallel metal rods with alternating radio frequency and direct current voltages to filter ions by their mass-to-charge ratio?
(A) Magnetic sector mass analyzer
(B) Quadrupole ion trap analyzer
(C) Time-of-Flight analyzer
(D) Linear quadrupole analyzer

2025

47. Consider the following statements regarding mass spectrometry ionization techniques:
I. Electron Impact (EI) involves bombardment with a high-energy electron beam, causing extensive fragmentation.
II. Chemical Ionization (CI) utilizes a reagent gas to transfer charge, resulting in softer ionization than EI.
III. Electrospray Ionization (ESI) requires the analyte to be vaporized prior to introduction into the high vacuum.
IV. MALDI uses a laser-absorbing organic matrix to facilitate ionization of large biomolecules.
V. Both ESI and MALDI are considered hard ionization techniques.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) III and V
(C) II, IV and V
(D) I, III and IV

2001

48. In ESR spectroscopy, the dimensionless constant that determines the exact resonance position of a paramagnetic species in a magnetic field is known as the:
(A) Chemical shift parameter
(B) Spin quantum number
(C) Lande g-factor
(D) Coupling constant

2016

49. Online calorific value measurements of flue gases most commonly depend on determining the concentration of:
(A) Carbon dioxide
(B) Water vapor
(C) Combustible gases such as methane and carbon monoxide
(D) Nitrogen oxides

2015

50. The paramagnetic susceptibility of oxygen decreases as:
(A) Temperature increases
(B) Gas velocity increases
(C) Humidity decreases
(D) Pressure decreases

2018

51. Select the correct sequence of detector components traversed by an ion in a Time-of-Flight (TOF) mass spectrometer.
(A) Flight tube, ion source, reflectron, detector
(B) Ion source, flight tube, reflectron, detector
(C) Ion source, reflectron, flight tube, detector
(D) Reflectron, ion source, flight tube, detector

2022

52. Non-Dispersive Infrared (NDIR) sensors distinguish specific gases, such as CO, by utilizing:
(A) A high-resolution grating monochromator
(B) A broad-spectrum optical filter and reference gas cells
(C) A chemiluminescent reaction chamber
(D) A photomultiplier tube tuned to visible wavelengths

NODIA

2005

53. Which UV fluorescence monitor principle is actively applied for detecting sulfur dioxide (SO_2) in ambient air?
(A) Excitation of SO_2 by UV light and measurement of subsequent fluorescent emission
(B) Absorption of UV light corresponding to an electronic transition to a non-radiative state
(C) Chemical reaction of SO_2 with ozone producing UV light
(D) Thermal decomposition of SO_2 releasing a UV photon

2. Entire sample aspirated reaches the flame
3. Generates a laminar, quiet flame
4. Initial desolvation of droplets occurs here

(A) P-3, Q-2, R-4, S-1
(B) P-2, Q-3, R-1, S-4
(C) P-1, Q-4, R-2, S-3
(D) P-4, Q-1, R-3, S-2

2013

36. In Atomic Absorption Spectrophotometry, what is the primary purpose of a graphite furnace?
(A) To provide a continuous spectrum for background correction
(B) To atomize the sample via intense electrical resistive heating
(C) To mechanically disperse the sample into an aerosol
(D) To filter out specific non-analyte emission lines

2012

37. Background correction in AAS to compensate for molecular absorption and light scattering is most frequently achieved using:
(A) A cooler flame profile
(B) A deuterium continuum lamp
(C) A secondary hollow cathode lamp
(D) Slower sample aspiration rates

2001

38. The signal detection mechanism in modern ICP-AES instruments typically utilizes:
(A) A single photomultiplier tube dedicated to each element
(B) A highly sensitive thermal conductivity detector
(C) A standard gas-phase electron capture detector
(D) Solid-state detector arrays (CCD or CID)

2004

39. Consider the following statements regarding fundamental chromatography concepts:
I. A higher number of theoretical plates indicates lower column efficiency.
II. The partition coefficient is the ratio of solute concentration in the stationary phase to that in the mobile phase.
III. An increase in column temperature generally increases the retention time in GC.
Which of the above statement(s) is/are INCORRECT?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2016

40. In Gas Chromatography, which carrier gas is generally preferred when using a Thermal Conductivity Detector (TCD) to ensure maximum sensitivity?
(A) Helium or Hydrogen
(B) Carbon Dioxide
(C) Nitrogen or Argon
(D) Oxygen

2014

41. Capillary columns in GC differ from packed columns primarily in that they:
(A) Contain an inert solid support packed densely within the column core
(B) Offer comparatively lower resolution for separating complex mixtures
(C) Require exceptionally high volumes of sample during injection
(D) Are open tubular columns with a coated inner wall

2021

42. In reversed-phase HPLC, if a highly polar analyte is analyzed, it will:
(A) Elute earlier than a non-polar analyte
(B) Elute later than a non-polar analyte
(C) Bind irreversibly to the non-polar stationary phase
(D) Be undetectable by standard UV-Vis detectors

2015

43. Consider the following statements concerning HPLC high-pressure pump mechanisms:
I. Reciprocating pumps provide a continuous flow but introduce pulsations.
II. Syringe pumps offer completely pulse-free flow but have limited reservoir capacity.
III. Pulse dampers are utilized to minimize flow rate fluctuations.
IV. Dual-piston pumps are rarely used due to their inability to perform gradient elution.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) I, III and IV
(C) II and IV
(D) I and II

2017

44. An Evaporative Light Scattering Detector (ELSD) in HPLC is uniquely beneficial because it:
(A) Relies strictly on the presence of a

Downloaded from www.pdf.tube

Q. Ilkovic equation
R. Dropping Mercury Electrode
S. Supporting electrolyte

List II: Definitions

1. Constantly renews the electrode surface
2. Reduces the migration current to negligible levels
3. Relates diffusion current to analyte concentration
4. Characteristic value identifying the electroactive species

(A) P-2, Q-3, R-1, S-4
(B) P-3, Q-4, R-2, S-1
(C) P-1, Q-2, R-4, S-3
(D) P-4, Q-3, R-1, S-2

2022

64. The Clark electrode measures dissolved oxygen by maintaining a constant applied potential sufficient to:
(A) Oxidize oxygen to water
(B) Reduce oxygen to hydroxide ions
(C) Reduce water to hydrogen gas
(D) Oxidize chloride ions

2006

65. In the context of industrial specific ion analyzers, what is the primary role of an ionic strength adjustment buffer (ISAB)?
(A) To selectively bind interferents
(B) To dilute the sample to infinite concentration
(C) To maintain a constant background ionic strength, fixing the activity coefficient
(D) To alter the pH to match the reference electrode

2003

66. Molar absorptivity (ε) in the Beer-Lambert law is dependent on which of the following variables?
(A) Physical path length of the cuvette
(B) Wavelength of the incident light beam
(C) Total intensity of the incident radiation
(D) Analyte concentration

2015

67. Consider the following statements regarding UV-VIS Spectrophotometry detectors:
I. A photomultiplier tube contains a series of dynodes to amplify the electron signal.
II. Photodiodes are typically less sensitive than photomultiplier tubes.
III. A diode array detector cannot scan multiple wavelengths simultaneously.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2005

68. Double beam optics in spectrophotometry correct for which primary source of instrumental error?
(A) Changes in ambient temperature
(B) Variations in sample path length
(C) Solvent evaporation
(D) Fluctuations in the radiant source intensity

2021

69. In Fourier Transform Infrared (FTIR) spectroscopy, the mathematical transformation converts the measured interferogram from the:
(A) Time domain to the frequency domain
(B) Frequency domain to the time domain
(C) Absorbance domain to the transmittance domain
(D) Spatial domain to the time domain

2010

70. Thermal detectors, such as bolometers, used in IR spectroscopy operate by measuring the change in:
(A) Electrical resistance as a function of absorbed heat
(B) Emitted photons from a heated surface
(C) Gas pressure within a sealed chamber
(D) Magnetic susceptibility of a crystal

NODIA

2013

71. Consider the following statements regarding Raman spectroscopy:
I. Rayleigh scattering is elastic and represents the majority of scattered photons.
II. Anti-Stokes lines occur when the molecule drops from a higher vibrational state to the ground state, releasing higher energy photons.
III. Raman scattering is completely dependent on the presence of a permanent dipole moment in the molecule.
IV. Raman spectroscopy is often used complementary to IR spectroscopy.
Which of the above statement(s) is/are INCORRECT?
(A) I and III
(B) II and IV
(C) I, II and IV
(D) III only

(ELSD)

2002

17. The Larmor frequency in Nuclear Magnetic Resonance (NMR) refers directly to the:
(A) Precessional frequency of the magnetic moment of a nucleus
(B) Rate of spin state relaxation back to equilibrium
(C) Rotational frequency of the sample tube in the probe
(D) Pulse duration required to flip the magnetization vector

2001

18. Which ionization technique in mass spectrometry is considered a "soft" ionization method ideal for analyzing large biomolecules with minimal fragmentation?
(A) High-energy Electron Impact ionization
(B) Gas-phase Chemical Ionization technique
(C) Inductively Coupled Plasma ionization
(D) Matrix-Assisted Laser Desorption Ionization (MALDI)

2008

19. Consider the following statements regarding Electron Spin Resonance (ESR) spectroscopy:
I. ESR requires the presence of unpaired electrons in the analyte.
II. The Zeeman effect describes the splitting of energy levels in an applied magnetic field.
III. The g-factor is entirely independent of the chemical environment of the free radical.
IV. DPPH is commonly used as a standard for g-factor calibration.
V. ESR primarily detects transitions in the X-ray region of the electromagnetic spectrum.
Which of the above statement(s) is/are correct?
(A) I, III and V
(B) II, IV and V
(C) I, II and IV
(D) I, II, III and IV

2001

20. In continuous flue gas analysis, what principle does the Katharometer bridge circuit rely upon?
(A) Differential thermal conductivity between the sample gas and a reference gas
(B) Paramagnetic properties of carbon dioxide
(C) Electrochemical reduction of sulfur dioxide
(D) Infrared absorption spectra of unburned hydrocarbons

2006

21. Which material forms the solid electrolyte in a high-temperature oxygen analyzer?
(A) Potassium chloride in an agar gel
(B) Zirconium oxide stabilized with yttria
(C) Platinum on a carbon support
(D) Lead zirconate titanate

2021

22. In industrial pollution monitoring, which method is standard for the continuous detection of nitrogen oxides (NOx)?
(A) Non-Dispersive Infrared spectroscopy
(B) Flame Atomic Absorption Spectrophotometry
(C) Pulsed UV fluorescence monitoring
(D) Chemiluminescence with ozone

2003

23. Select the correct sequence of operating regions in a gas-filled nuclear radiation detector as applied voltage increases.
(A) Recombination region, Ionization region, Proportional region, Geiger-Muller region
(B) Recombination region, Proportional region, Ionization region, Geiger-Muller region
(C) Proportional region, Recombination region, Ionization region, Geiger-Muller region
(D) Ionization region, Proportional region, Recombination region, Geiger-Muller region

2022

24. Solid-state semiconductor detectors offer an advantage over NaI scintillation counters in Gamma Spectrometry primarily due to:
(A) Lower cost of maintenance
(B) Operation strictly at room temperature without cooling
(C) Superior energy resolution
(D) Larger detection volume for high-efficiency counting

2003

25. In Derivative Thermo Gravimetric Analysis (DTGA), what specific variable is plotted on the y-axis against temperature or time?
(A) Absolute cumulative mass of the sample
(B) Exothermic and endothermic heat flow
(C) Specific heat capacity of material
(D) Rate of mass change $(\frac{dm}{dt})$

2006

26. Which reference electrode is most widely used in practical electroanalytical measurements due to its stability and ease of preparation?
(A) Saturated Calomel Electrode
(B) Standard Hydrogen Reference Electrode

Click Here to Buy book on Amazon

(D) Wavenumbers (cm^{-1})

2025

82. Which reference compound is historically utilized to set the zero point (0 ppm) in ^{1}H and ^{13}C NMR spectroscopy?
(A) Deuterated chloroform ($CDCl_3$)
(B) Dichloromethane
(C) Dimethyl sulfoxide (DMSO)
(D) Tetramethylsilane (TMS)

2015

83. Match the mass spectrometry terms in List I with their corresponding descriptions in List II.
List I: Mass Spectrometry Terms
P. Base peak
Q. Molecular ion peak
R. $\frac{m}{z}$ ratio
S. Isotope peak
List II: Corresponding Descriptions
1. The unfragmented radical cation of the analyte
2. The most intense peak in the mass spectrum (100% relative abundance)
3. Arises due to natural occurrence of heavy isotopes (e.g., ^{13}C)
4. The fundamental parameter measured by the mass analyzer
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-3, R-1, S-2

2016

84. Which mass analyzer provides the highest mass resolution by trapping ions in cyclical orbits and detecting their image current?
(A) Single quadrupole
(B) Fourier Transform Ion Cyclotron Resonance (FT-ICR)
(C) Linear ion trap
(D) Triple quadrupole

2009

85. The application of ESR spectroscopy is most critical for investigating which type of chemical species?
(A) Transient free radicals
(B) Closed-shell diamagnetic molecules
(C) Stable noble gas atoms
(D) Highly symmetrical aromatic rings

2008

86. In flue gas analysis, the thermal conductivity of a gas mixture is compared against a reference gas, typically:
(A) Air or Nitrogen
(B) Pure Carbon Dioxide
(C) Water vapor
(D) Sulfur dioxide

2018

87. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Zirconium oxide high-temperature sensors must be heated to at least 600°C to function effectively as oxygen analyzers.
Reason (R): Zirconium oxide becomes a conductor of oxygen ions only at elevated temperatures.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

88. Chemiluminescence analyzers measure NOx by combining NO with ozone to produce an excited state of NO_2, which then:
(A) Absorbs specific wavelengths of infrared radiation
(B) Undergoes rapid thermal degradation to nitrogen and oxygen
(C) Emits a photon on ground-state decay
(D) Reacts immediately with an added fluorescent dye

2025

89. A Gas-filled proportional counter differs functionally from a GM counter in that the proportional counter's output pulse amplitude is:
(A) Completely constant regardless of the incoming radiation energy level
(B) Significantly lower than that of a standard parallel-plate ionization chamber
(C) Exclusively dependent upon the gas temperature inside the active chamber
(D) Proportional to deposited radiation energy

NODIA

2005

90. Sodium Iodide (NaI) crystals used in scintillation counting are typically doped with which element to act as a luminescence activator?
(A) Silicon (Si)
(B) Thallium (Tl)
(C) Germanium (Ge)
(D) Lithium (Li)

(B) Operating at low pressure and relatively low temperature to minimize Doppler and collisional broadening
(C) Utilizing a continuously variable magnetic field
(D) Coating the lamp with a dense polymer

2014
153. One major advantage of Inductively Coupled Plasma (ICP) over Atomic Absorption Spectrophotometry (AAS) is that ICP:
(A) Permits simultaneous multi-element analysis over a wide linear dynamic range
(B) Operates at much lower temperatures, protecting the sample from degradation
(C) Requires significantly simpler and less expensive instrumentation
(D) Consumes no gases during operation

2006
154. In chromatographic theory, eddy diffusion (the A term in the van Deemter equation) describes band broadening caused by:
(A) The longitudinal diffusion of the solute in the mobile phase
(B) The multiple paths of different lengths that solute molecules can travel through a packed column
(C) Mass transfer resistance in the stationary phase
(D) The thermal decomposition of the solute

2001
155. Which statement accurately describes splitless injection in Gas Chromatography?
(A) The entire injected sample is directed to the capillary column, useful for trace analysis
(B) Only a small fraction (e.g., 1%) of the sample enters the column to prevent overloading
(C) It is utilized with packed columns
(D) The sample is injected directly into a flame

2005
156. In High-Performance Liquid Chromatography (HPLC), a "guard column" is frequently installed before the analytical column to:
(A) Trap contaminants to protect the analytical column
(B) Accelerate and stabilize the flow of mobile phase
(C) Provide high-resolution separation of closely eluted peaks
(D) Degas the mobile phase to prevent bubble formation

2012
157. A fluorescence detector in HPLC is highly sensitive but relies fundamentally on the analyte's ability to:
(A) Absorb light at one wavelength and emit light at a longer wavelength
(B) Alter the refractive index of the mobile phase
(C) Scatter a laser beam into a photodiode
(D) Conduct an electrical current

2025
158. In NMR, nuclei with a spin quantum number (I) equal to zero (e.g., ^{12}C, ^{16}O) will:
(A) Exhibit extremely complex multiplet splitting patterns
(B) Be highly visible in standard NMR spectra
(C) Possess no magnetic moment and thus be NMR inactive
(D) Resonate at infinitely high frequencies

2011
159. The Quadrupole mass analyzer filters ions based on the stability of their trajectories through an oscillating electric field created by combining:
(A) High temperature and a vacuum pump
(B) An intense magnetic field and a radio frequency field
(C) Radio frequency (RF) and Direct Current (DC) voltages
(D) An electron beam and a photon beam

2012
160. Which standard is widely utilized to calibrate the exact magnetic field and microwave frequency (the g-factor) in an ESR spectrometer?
(A) Tetramethylsilane (TMS)
(B) 2,2-Diphenyl-1-picrylhydrazyl (DPPH)
(C) Deuterium oxide
(D) Potassium bromide (KBr)

2005
161. In the context of flue gas analysis, what does a high concentration of carbon monoxide (CO) typically indicate?
(A) An excess of combustion air
(B) Incomplete combustion due to insufficient oxygen or poor mixing
(C) A malfunction in the thermal conductivity detector
(D) Complete and highly efficient combustion

2005
162. The magneto-dynamic (paramagnetic) oxygen analyzer operates by utilizing a small glass dumbbell suspended in a magnetic field. When

Downloaded from www.pdf.tube

(B) $v_s < v_0$
(C) $v_s > v_0$
(D) $v_s = 0$

2004

101. Which specific burner type in Flame Emission Spectrophotometry creates a laminar flow, ensuring a stable and relatively noise-free flame?
(A) Direct injection burner
(B) Total consumption burner
(C) Premix (laminar flow) burner
(D) Meker burner

2017

102. In Atomic Absorption Spectrophotometry, graphite furnace atomization provides higher sensitivity than flame atomization because:
(A) The atomic vapor resides in the optical path for a significantly longer time.
(B) It utilizes a much higher sample volume per reading.
(C) It inherently prevents the formation of any interfering molecular species.
(D) It employs a higher intensity hollow cathode lamp.

2025

103. Inductively Coupled Plasma (ICP) operates primarily in which phase of matter?
(A) Liquid
(B) Solid
(C) Gas
(D) Plasma

2011

104. Which term describes the degree of separation between two adjacent peaks in a chromatogram?
(A) Retention time
(B) Plate height
(C) Resolution
(D) Selectivity factor

2014

105. In Gas Chromatography, the Flame Ionization Detector (FID) is practically insensitive to which of the following compounds?
(A) Hexane
(B) Benzene
(C) Ethanol
(D) Water

2019

106. In HPLC, the mechanism of isocratic elution refers to utilizing a mobile phase wherein the:
(A) Temperature continuously changes during the run
(B) Solvent composition remains constant throughout the run
(C) Flow rate is steadily increased
(D) Pressure is oscillated sequentially

2024

107. Which of the following is a primary disadvantage of a Refractive Index (RI) detector in HPLC?
(A) It destroys the sample during analysis.
(B) It is highly sensitive to trace concentrations.
(C) It is incompatible with gradient elution.
(D) It only detects compounds containing conjugated double bonds.

NODIA

2016

108. Continuous wave (CW) NMR has largely been superseded by Fourier Transform NMR (FT-NMR) because FT-NMR provides:
(A) Significantly improved sensitivity and faster data acquisition via pulse techniques
(B) Eradication of all spin-spin coupling effects
(C) Slower but more mechanically stable magnetic sweeping
(D) The ability to analyze solid-phase samples without any solvent

2008

109. In Mass Spectrometry, the primary function of the mass analyzer is to separate ions based directly upon their:
(A) Absolute mass
(B) Kinetic energy
(C) Mass-to-charge ratio ($\frac{m}{z}$)
(D) Magnetic dipole moment

2018

110. Which subatomic property is uniquely interrogated by Electron Spin Resonance (ESR) spectroscopy?
(A) Nuclear spin states
(B) Proton translational kinetic energy
(C) Unpaired electron spin
(D) Resonant neutron transitions

2003

111. In thermal conductivity detectors used for flue gas analysis, the Katharometer elements are typically arranged in which electrical configuration?
(A) A simple electrical series circuit
(B) An integrated parallel capacitor array
(C) A standard Kelvin double bridge loop
(D) A classic Wheatstone bridge

2010

112. Why is the paramagnetic property of oxygen utilized in continuous industrial gas analyzers?
(A) Because oxygen is repelled by magnetic fields, cooling the sensor.
(B) Because oxygen is uniquely attracted into a magnetic field, altering a measurable physical parameter (like flow or thermal convection).
(C) Because it causes oxygen to emit a characteristic red light
(D) Because oxygen molecules split into ions under magnetic influence.

2005

113. Non-Dispersive Infrared (NDIR) technology for detecting carbon monoxide relies on the fact that CO absorbs IR radiation at a specific wavelength. Which component prevents interference from other IR-absorbing gases?
(A) A gas filter correlation wheel or specific optical bandpass filter
(B) A diffraction grating
(C) A lead sulfide photodiode
(D) A continuous UV source

2015

114. The "dead time" of a Geiger-Muller detector refers to the period during which:
(A) The detector requires calibration.
(B) The detector cannot record a subsequent ionizing event due to positive ion sheath accumulation.
(C) The radioactive source has fully decayed.
(D) No gas is present in the chamber

2014

115. A high-purity Germanium (HPGe) detector used in gamma spectrometry must be cooled with liquid nitrogen during operation to:
(A) Prevent the physical melting of the solid-state contacts
(B) Maximize the thermal noise generated by the crystal
(C) Reduce thermal generation of electron-hole pairs (leakage current)
(D) Enhance the kinetic energy of the incoming gamma rays

2012

116. In Differential Scanning Calorimetry (DSC), the glass transition temperature (T_g) of a polymer is typically observed as a:
(A) Sharp endothermic peak
(B) Sharp exothermic peak
(C) Sudden mass loss on the curve
(D) Step change in the baseline heat capacity

2019

117. An indicator electrode in electroanalytical chemistry is defined as the electrode:
(A) Whose potential remains completely constant under all conditions
(B) That provides a stable reference potential
(C) Whose potential responds to the activity of the analyte in solution
(D) That physically changes color during the reaction

2012

118. When a glass pH electrode is subjected to very low pH (acid error), the measured pH tends to be:
(A) Systematically lower than the actual pH value
(B) Completely unaffected by solution conditions
(C) Driven exactly to a value of zero
(D) Higher than the actual pH value

2023

119. Platinization of the platinum electrodes in a conductivity cell is performed to:
(A) Increase the effective surface area and minimize polarization effects
(B) Prevent the electrodes from reacting with acids
(C) Decrease the mechanical strength of the electrodes
(D) Lower the intrinsic cell constant to zero

2023

120. In polarography, the removal of dissolved oxygen from the analyte solution prior to measurement is necessary because:
(A) Oxygen physically blocks the capillary tube
(B) Oxygen reacts explosively with mercury
(C) Oxygen oxidizes the supporting electrolyte
(D) Oxygen is electroactive and produces two interfering reduction waves

2019

121. For specific ion analysis of trace sodium in water, alkaline buffers (like ammonia) are added to the sample to:
(A) Prevent hydrogen ion (H^+) interference at the glass membrane
(B) Neutralize the sodium ions
(C) Etch the electrode surface for better response
(D) Precipitate interfering calcium ions

Click Here to Buy book on Flipkart

2022

122. The unit of molar absorptivity (ε) when concentration is in mol/L and path length is in cm is:
(A) $\text{mol} \cdot \text{L}^{-1} \cdot \text{cm}$
(B) $\text{L} \cdot \text{mol}^{-1} \cdot \text{cm}^{-1}$
(C) $\text{cm} \cdot \text{mol}^{-1}$
(D) $\text{L} \cdot \text{g}^{-1} \cdot \text{cm}^{-1}$

2010

123. Which phenomenon occurs when a single chromophore interacts with high-intensity radiation, temporarily depleting the ground state population, causing a deviation in Beer's Law?
(A) Stray light error
(B) Saturation
(C) Chemical shift
(D) Fluorescence quenching

2008

124. In FTIR, the term "apodization" refers to a mathematical process used to:
(A) Convert the transmittance spectrum to absorbance
(B) Align the moving mirror exactly with the stationary mirror
(C) Correct the instrumental baseline drift
(D) Reduce the artifactual side-lobes in the transformed spectrum caused by truncation of the interferogram

2021

125. The intensity of Raman scattered light is highly dependent on the:
(A) Refractive index of the cuvette alone
(B) Changes in the polarizability of the molecule during a vibration
(C) Permanent magnetic dipole of the molecule
(D) Absorbance of the sample at the laser wavelength

2019

126. A prominent limitation of Flame Emission Spectrophotometry compared to Atomic Absorption Spectrophotometry is that emission is highly susceptible to:
(A) The physical coloration and turbidity of the analyte solution
(B) The background presence of unreactive noble gas carriers
(C) Fluctuations in the flame temperature
(D) The geometric dimensions and optical path of the sample cuvette

2010

127. Chemical interferences in AAS due to refractory compound formation (like calcium phosphate) are typically mitigated by:
(A) Using a cooler flame such as Air-Methane
(B) Adding a releasing agent like Lanthanum or Strontium
(C) Decreasing the slit width of the monochromator
(D) Diluting the sample heavily with water

2019

128. In ICP-AES, the argon gas serves multiple purposes. Which of the following is NOT one of its functions?
(A) Acting as the plasma gas that sustains the electrical discharge
(B) Serving as an auxiliary gas to cool the quartz torch
(C) Undergoing combustion to generate thermal heat
(D) Acting as the nebulizer gas to transport the sample aerosol

2013

129. The theoretical plate height (H) in chromatography is related to the column length (L) and number of theoretical plates (N) by the equation:
(A) $H = \frac{L}{N}$
(B) $H = \frac{N}{L}$
(C) $H = L \times N$
(D) $H = \frac{N^2}{L}$

2012

130. A Flame Ionization Detector (FID) in GC operates by measuring the current produced by:
(A) Free electrons continuously emitted from a radioactive Nickel-63 foil
(B) Temperature-induced changes in the thermal conductivity of the carrier gas
(C) Selective electronic absorption of UV radiation by aromatic rings
(D) Ion currents produced in a hydrogen-air flame

2016

131. In a typical reversed-phase HPLC separation using a C18 column, if the mobile phase polarity is decreased (e.g., adding more methanol to water), the retention times of hydrophobic analytes will:

Downloaded from www.pdf.tube

(A) Decrease
(B) Remain unchanged
(C) Increase
(D) Become infinite

2004

132. The primary operational advantage of a diode array detector (DAD) in HPLC over a standard variable wavelength UV-Vis detector is its ability to:
(A) Acquire full-range UV-Vis absorption spectra continuously in real-time
(B) Selectively detect complex non-chromophoric chemical substances
(C) Estimate eluting molecular weights
(D) Operate reliably without an integrated radiation source assembly

2002

133. The continuous wave (CW) NMR spectrometer achieves resonance by holding the radiofrequency constant and slowly sweeping the:
(A) Sample temperature
(B) External magnetic field strength
(C) Sample rotation speed
(D) Internal probe pressure

2025

134. Which ionization method in mass spectrometry would most likely produce a mass spectrum dominated by a prominent molecular ion peak $[M]^+$ or $[M+H]^+$ with very little fragmentation?
(A) Standard Electron Impact (EI) at 70 eV
(B) Atmospheric Electrospray Ionization (ESI)
(C) Inductively Coupled Plasma (ICP) discharge
(D) Collision-induced dissociation

2012

135. In an ESR spectrum of a free radical, hyperfine splitting occurs as a result of the interaction between the unpaired electron and:
(A) The external magnetic field exclusively
(B) Earth's gravitational field
(C) Neighboring magnetic nuclei (such as protons)
(D) The microwave radiation frequency directly

2021

136. An online flue gas analyzer measuring unburned combustibles often relies on a catalytic bead sensor (pellistor). The principle involves measuring the:
(A) Increase in resistance due to the heat of catalytic oxidation of the combustibles
(B) Decrease in pressure as gases condense
(C) Fluorescence emitted by the burning gases
(D) Infrared transmittance of the combustion products

NODIA

2010

137. In a Zirconium oxide oxygen sensor, the voltage generated across the cell is logarithmically proportional to the ratio of:
(A) The partial pressures of oxygen across the solid electrolyte
(B) The pressure of carbon dioxide in the two gas streams
(C) The flow rates of the sample and reference gases
(D) The temperatures of the anode and cathode

2015

138. Which technique is most commonly employed in industrial continuous emission monitoring systems (CEMS) to ensure accurate baseline calibration of a gas analyzer?
(A) Manual injection of standard liquid compounds
(B) Replacing the primary sensing detector weekly
(C) Zero and span gas calibration routines
(D) Flushing the analytical system with pure water

2001

139. A gas-filled detector operating in the ionization region relies on collecting:
(A) Secondary ion pairs created by gas multiplication
(B) Electron avalanches triggered by single photons
(C) Light photons emitted by excited gas molecules
(D) Primary ion pairs created without multiplication

2008

140. Scintillation counters utilizing NaI(Tl) crystals convert incident gamma-ray energy primarily into:
(A) Visible light photons
(B) Alpha particles
(C) Radiofrequency waves
(D) Acoustic phonons

2008

141. The primary purpose of using a purge gas (e.g., nitrogen or argon) during Thermogravimetric Analysis (TGA) is to:
(A) Provide a controlled environment and remove evolved gaseous decomposition products
(B) React chemically with the sample to lower

its melting point
(C) Cool the sample rapidly to room temperature
(D) Increase the buoyant force on the microbalance

2008

142. A saturated calomel electrode (SCE) consists of mercury in contact with solid mercury(I) chloride (calomel) bathed in a saturated solution of:
(A) Silver chloride
(B) Potassium chloride
(C) Sodium hydroxide
(D) Sulfuric acid

2009

143. Which factor primarily dictates the required frequency of pH meter calibration in an industrial setting?
(A) The atmospheric pressure in the laboratory
(B) The time of day the measurement is taken
(C) The gradual shift in the asymmetry potential of the glass electrode over time
(D) The rotation speed of the magnetic stirrer

2017

144. According to Kohlrausch's law, the molar conductivity of an infinite dilution of acetic acid (CH_3COOH) can be determined by the sum of the limiting molar conductivities of which combination?
(A) $HCl + CH_3COONa - NaCl$
(B) $NaCl + CH_3COONa - HCl$
(C) $CH_3COONa - HCl$
(D) $HCl + NaCl - CH_3COONa$

2005

145. In a polarogram, the current observed prior to the initiation of the analyte's reduction or oxidation is termed the:
(A) Diffusion current
(B) Residual current
(C) Catalytic current
(D) Limiting current

2006

146. For the detection of trace silica in boiler water, the heteropoly blue method relies on the reduction of molybdosilicic acid. What spectrophotometric principle is applied?
(A) Measurement of fluorescence emission at 800 nm
(B) Measurement of flame atomic emission spectra
(C) Measurement of absorbance near 815 nm
(D) Measurement of analyte mass-to-charge ratio

2008

147. A plot of absorbance versus concentration is linear. According to the Beer-Lambert law, if the path length is doubled and the concentration is halved, the measured absorbance will:
(A) Double its original value
(B) Remain unchanged
(C) Halve its original value
(D) Quadruple its original value

2010

148. The primary function of the exit slit in a UV-Vis spectrophotometer monochromator is to:
(A) Refract the light into its component colors
(B) Focus the light onto the sample cuvette and determine the spectral bandwidth
(C) Generate continuous radiation
(D) Convert photons into electrical current

2018

149. In FTIR spectroscopy, what is a distinct advantage over dispersive IR instruments?
(A) The Jacquinot advantage (high throughput of energy)
(B) Slower scanning speed allowing for thermal equilibration
(C) Complete elimination of water vapor absorption
(D) Lack of requirement for a moving mirror

2006

150. Rayleigh scattering differs from Raman scattering in that Rayleigh scattering is:
(A) Inelastic, with a change in photon energy
(B) Elastic, with no change in the energy of the scattered photon
(C) Dependent on permanent molecular dipoles
(D) Observable only in the ultraviolet region

2008

151. In a flame emission spectrometer, why is a narrow spectral bandpass necessary?
(A) To decrease the temperature of the flame
(B) To increase the total light throughput to the detector
(C) To isolate the specific emission line of the analyte from background emission and adjacent lines
(D) To ionize the atoms more efficiently

2007

152. In an atomic absorption spectrometer, what limits the broadening of the emission line profile produced by the hollow cathode lamp?
(A) Operating at high pressure and high temperature

Click Here to Buy book on Amazon

(D) Polyvinyl chloride with a neutral carrier ligand

2014

172. According to the Beer-Lambert Law, if the transmittance of a solution is 10%, what is its absorbance?
(A) 0.1
(B) 1.0
(C) 2.0
(D) 10.0

2009

173. The function of a grating monochromator in a spectrophotometer is based on the optical principle of:
(A) Simple refraction through a prism
(B) Diffraction and interference
(C) Total internal reflection
(D) Isotropic scattering

2001

174. Which component in an FTIR spectrometer is directly responsible for measuring the intensity of the infrared radiation after it passes through the sample?
(A) The Michelson interferometer
(B) The Globar source
(C) The thermal or pyroelectric detector (e.g., DTGS)
(D) The Helium-Neon laser

2015

175. The Stokes and Anti-Stokes lines in a Raman spectrum are arranged symmetrically around the central:
(A) Zero-point energy level
(B) Absorption peak of the solvent
(C) Rayleigh scattering line
(D) Incident microwave frequency

2005

176. Which process must occur before atomization can take place in a flame emission spectrophotometer?
(A) Electronic excitation
(B) Desolvation and volatilization of the aerosol
(C) Ionization of the analyte
(D) Photoelectric emission

2017

177. Spectral interference in AAS occurs when:
(A) Matrix elements form thermally stable oxides
(B) An emission line of an interfering element overlaps the analyte absorption line
(C) The sample viscosity changes the aspiration rate
(D) The analyte reacts with the fuel gas

2023

178. What is the fundamental excitation mechanism utilized in Inductively Coupled Plasma Atomic Emission Spectrophotometry (ICP-AES)?
(A) Resistive heating of a graphite tube under inert gas atmosphere
(B) Direct absorption of photons emitted by a hollow cathode lamp
(C) Collisional excitation within a high-temperature argon plasma
(D) Chemical combustion reactions of acetylene and nitrous oxide

2024

179. In chromatography, if the partition coefficient of solute A is greater than that of solute B, solute A will:
(A) Elute faster than solute B
(B) Co-elute with solute B
(C) Have a stronger affinity for the stationary phase and elute later
(D) Never enter the stationary phase

2011

180. A Thermal Conductivity Detector (TCD) in Gas Chromatography is considered a:
(A) Mass-sensitive, destructive detector
(B) Concentration-sensitive, non-destructive detector
(C) Highly specific detector for halogenated compounds
(D) Detector reliant on ionization via a hydrogen flame

2013

181. Normal-phase HPLC utilizes a stationary phase that is:
(A) Highly polar, such as bare silica
(B) Highly non-polar, such as C18 functionalized silica
(C) A volatile organic solvent
(D) An ion-exchange resin only

NODIA

2011

182. Which of the following parameters does NOT directly affect the baseline stability of an HPLC Refractive Index (RI) detector?
(A) Extreme temperature fluctuations
(B) Analyte concentration changes
(C) Small changes in mobile phase composition
(D) The absence of chromophores in the sample

oxygen enters the chamber, it alters the magnetic field, causing the dumbbell to:
(A) Melt under intense thermal stress
(B) Change color from clear to bright red
(C) Rotate within the active magnetic field
(D) Emit a high-frequency radio signal

2024

163. NDIR instruments used for environmental monitoring frequently utilize a "chopper" wheel to:
(A) Physically cut the gas sample into smaller volumes
(B) Cool the infrared source to prevent overheating
(C) Modulate the IR beam, creating an alternating signal that is easier to amplify and distinguish from background noise
(D) Continuously alter the wavelength being emitted

2009

164. What is the primary function of a quenching gas, such as a halogen, in a Geiger-Muller tube?
(A) To absorb UV photons emitted during the avalanche and neutralize positive ions, preventing continuous discharge
(B) To increase the kinetic energy of the incident radiation
(C) To provide a visual flash of light for manual counting
(D) To increase the dead time to several minutes

2021

165. Gamma-ray spectrometry utilizing semiconductor detectors often exhibits a "Compton continuum." This spectral feature is the result of:
(A) Total absorption of the gamma ray via the photoelectric effect
(B) Incomplete energy deposition due to gamma rays scattering and escaping the detector
(C) Pair production resulting in two 511 keV annihilation peaks
(D) The natural background radiation of the earth

2014

166. In Thermogravimetric Analysis (TGA), the onset of a mass-loss event corresponds to a chemical or physical process such as:
(A) Phase transition without mass change (e.g., solid-solid transition)
(B) Simple glass transition (Tg)
(C) Thermal decomposition or vaporization
(D) Heat capacity shift

2018

167. Standard electrode potentials are fundamentally measured under standard state conditions. Which of the following defines standard state for aqueous solutes?
(A) Infinite dilution at 273.15 K
(B) A concentration of 1 Molar at 0 Kelvin
(C) An activity of exactly 1 at a specified temperature (commonly 298.15 K)
(D) Saturation point at standard atmospheric pressure

2025

168. A pH meter requires temperature compensation primarily because the:
(A) Nernst slope ($\frac{2.303RT}{F}$) is directly proportional to absolute temperature
(B) Glass electrode shatters at high temperatures
(C) Reference electrode potential drops to zero at 25°C
(D) Viscosity of the solution blocks the reference junction

2022

169. What role does alternating current (AC) play in Kohlrausch's method for determining the conductivity of an electrolyte?
(A) It prevents polarization of the electrodes and changes in local concentration
(B) It electrolyzes the solution to generate gas bubbles
(C) It ensures a direct proportional increase in temperature
(D) It aligns the dipole moments of the water solvent

2025

170. Which equation relates the polarographic diffusion current to the number of electrons transferred, diffusion coefficient, mercury flow rate, and drop time?
(A) Nernst equation
(B) Randles-Sevcik equation
(C) Ilkovic equation
(D) Cottrell equation

2011

171. A specific ion electrode for fluoride typically utilizes a crystalline membrane composed of:
(A) Silver chloride precipitate on a porous glass support
(B) Lanthanum fluoride crystal doped with europium
(C) Specially formulated aluminosilicate glass membrane

Downloaded from www.pdf.tube

2022

91. Match the thermal analysis techniques in List I with their primary measured parameters in List II.

List I: Thermal Analysis Techniques

P. Thermogravimetric Analysis (TGA)

Q. Differential Scanning Calorimetry (DSC)

R. Derivative Thermogravimetry (DTG)

S. Differential Thermal Analysis (DTA)

List II: Primary Measured Parameters

1. Temperature difference between sample and reference
2. Rate of mass change with respect to temperature
3. Absolute change in mass
4. Heat flow required to maintain sample and reference at the same temperature

(A) P-1, Q-2, R-3, S-4

(B) P-3, Q-4, R-2, S-1

(C) P-4, Q-3, R-1, S-2

(D) P-2, Q-1, R-4, S-3

2004

92. In potentiometry, which term describes the potential difference that arises at the interface of two electrolyte solutions of different compositions?

(A) Boundary potential

(B) Liquid junction potential

(C) Asymmetry potential

(D) Ohmic potential drop

2001

93. When measuring the pH of a solution containing high concentrations of proteins, which issue is most likely to affect the glass electrode?

(A) Complete evaporation of the internal buffer

(B) Dissolution of the glass membrane

(C) Reversal of the internal reference polarity

(D) Coating and fouling of the porous reference junction

2008

94. The limiting molar conductivity of a weak electrolyte at infinite dilution can be determined utilizing:

(A) Kohlrausch's law describing the independent migration of ions

(B) The standard Nernst equation applied directly to the solvent phase

(C) Direct extrapolation of its conductivity curve

(D) The classic Beer-Lambert optical law evaluated at low concentrations

2024

95. The Ilkovic equation demonstrates that the diffusion current in polarography is directly proportional to the:

(A) Dropping rate of the mercury electrode squared

(B) Applied voltage at the reference electrode

(C) Resistance of the supporting electrolyte

(D) Concentration of the electroactive species

2012

96. In industrial water analysis, trace sodium levels in high-purity boiler water are most effectively monitored using:

(A) An NDIR gas analyzer

(B) A sodium-selective glass electrode potentiometric system

(C) An evaporative light scattering detector

(D) A UV-fluorescence monitor

NODIA

2024

97. The deviation from Beer's Law observed when employing polychromatic light is primarily considered an:

(A) Environmental deviation

(B) Instrumental deviation

(C) Chemical deviation

(D) Anthropogenic deviation

2025

98. In a UV-Vis spectrophotometer, which radiation source is used for the visible spectrum (350 - 800 nm)?

(A) Deuterium arc source

(B) Xenon flash tube

(C) Hollow cathode lamp

(D) Tungsten lamp

2015

99. The Michelson interferometer in an FTIR spectrometer generates an interferogram by splitting light and recombining it after one beam travels a:

(A) Curved path through a refractive prism

(B) Fixed distance and the other through a varying magnetic field

(C) Fixed distance and the other a continuously varying distance

(D) Varying distance determined by thermal expansion

2009

100. In Raman spectroscopy, if the incident laser has a frequency of v_0 and the scattered light has a frequency v_s, a Stokes shift occurs when:

(A) $v_s = v_0$

2007

183. In NMR spectroscopy, the process of spin-spin splitting obeys the "n+1 rule". The letter 'n' represents the:
(A) Total number of electrons in the molecule
(B) Number of identical nuclei causing the splitting
(C) Number of equivalent adjacent NMR-active nuclei
(D) Number of double bonds in the structure

2012

184. The Matrix-Assisted Laser Desorption/ Ionization (MALDI) technique uses an organic matrix to:
(A) Absorb the laser energy and protect the biomolecule from direct destructive heating
(B) React chemically with the biomolecule to form covalent bonds
(C) Generate a continuous stream of electrons for ionization
(D) Alter the magnetic field of the TOF analyzer

2002

185. In an ESR spectrum, a radical containing a single nucleus with a spin of I = 1 (such as ^{14}N) will produce a spectrum split into how many equally spaced lines?
(A) 1
(B) 2
(C) 3
(D) 4

2003

186. In the analysis of flue gases, the determination of online calorific value is most crucial for optimizing:
(A) The overall efficiency of the wet scrubber system
(B) The physical appearance and color of the stack plume
(C) The combustion efficiency and air-to-fuel ratio
(D) The size distribution of particulate matter exhausted

2016

187. A high-temperature Zirconium oxide oxygen sensor measures the concentration of oxygen by generating an electromotive force (EMF). This process is fundamentally based on:
(A) The Seebeck effect
(B) The Nernst equation applied to a concentration cell
(C) The Hall effect
(D) The Beer-Lambert law

2004

188. Which atmospheric pollutant is most reliably quantified using a UV fluorescence analyzer?
(A) Methane (CH_4)
(B) Carbon dioxide (CO_2)
(C) Ozone (O_3)
(D) Sulfur dioxide (SO_2)

2018

189. Operating a gas-filled detector in the Geiger-Muller region results in a Townsend avalanche that spreads along the entire anode. This means the output pulse size is:
(A) Directly proportional to the number of primary ion pairs
(B) Independent of the initial radiation type and energy
(C) Extremely small, requiring intense pre-amplification
(D) Used specifically to identify the energy of the incident photon

2008

190. What specific role does a photomultiplier tube (PMT) play in a scintillation counter system?
(A) It creates and collimates the initial burst of gamma radiation
(B) It converts light flashes into amplified electrical pulses
(C) It acts as a heavy physical shield blocking background radiation
(D) It actively cools the scintillator crystal to minimize thermal noise

2025

191. In Thermal Analysis, a Derivative Thermogravimetric (DTGA) curve plots the first derivative of the TGA curve. The peaks on a DTGA curve correspond precisely to:
(A) The temperatures of maximum rate of mass change
(B) The total mass remaining at the end of the experiment
(C) The specific heat capacity of the pure reference
(D) Exothermic phase transitions without mass loss

2022

192. Which equation determines the potential of an indicator electrode based on the activities of the oxidized and reduced species?
(A) Kohlrausch equation
(B) Nernst equation
(C) Beer's Law
(D) Ilkovic equation

Click Here to Buy book on Flipkart

(A) A solid-state diode
(B) A simple resistor
(C) A step-up transformer
(D) A mechanical relay

2006
216. In Differential Scanning Calorimetry (DSC), an exothermic reaction (such as crystallization) is typically plotted as a peak pointing in which direction relative to the baseline?
(A) It depends on the specific instrument convention (can be up or down, but is opposite to endothermic peaks)
(B) Always upwards, regardless of convention
(C) Always downwards, regardless of convention
(D) Exothermic reactions do not produce peaks in DSC

2019
217. Which term describes a reference electrode constructed using an internal element in contact with a solution saturated with a sparingly soluble salt of its metal?
(A) An electrode of the second kind
(B) A redox indicator electrode
(C) A glass membrane electrode
(D) A dropping mercury electrode

2019
218. When measuring pH in solutions with high ionic strength, activity coefficients must be considered because the glass electrode responds to:
(A) The physical mass of dissolved hydrogen ions
(B) The chemical activity of hydrogen ions
(C) The concentration of hydrogen ions
(D) The total titratable acidity of the solution

2014
219. The unit of cell constant for a conductivity cell is typically expressed as:
(A) cm
(B) cm^{-1}
(C) $S \cdot cm^2 \cdot mol^{-1}$
(D) $\Omega \cdot cm$

2001
220. In classical polarography, supporting electrolyte is added in large excess (typically 100-fold) to the analyte to suppress:
(A) The charging current
(B) The diffusion current
(C) The migration current
(D) The residual current

2019
221. For specific ion analyzers monitoring silica, what chemical agent is added to reduce the molybdosilicic acid complex to the detectable heteropoly blue form?
(A) An oxidizing agent like potassium permanganate
(B) Sodium hydroxide
(C) A reducing agent such as amino-naphthol-sulfonic acid (ANSA) or ascorbic acid
(D) Strong sulfuric acid alone

2021
222. The term "isosbestic point" in spectrophotometry refers to a specific wavelength where:
(A) Absorbance obeys Beer's Law at all concentrations
(B) Absorbing species share identical molar absorptivity
(C) Transmittance reaches exactly one hundred percent
(D) Stray light within the instrument is eliminated

NODIA

2021
223. In UV-VIS spectrophotometry, which material is essential for cuvette construction when making measurements below 350 nm (in the UV range)?
(A) Fused silica or quartz
(B) Standard borosilicate glass
(C) Molded polystyrene optical plastic
(D) Opaque Teflon

2018
224. The fundamental mechanism of an FTIR spectrometer involves obtaining an interferogram. This interferogram is a complex signal representing light intensity as a function of:
(A) The fixed position of the sample
(B) The optical path difference created by the moving mirror
(C) The rotation speed of the chopper wheel
(D) The temperature of the IR source

2007
225. In Raman spectroscopy, the energy difference between the incident photon and the Raman scattered photon corresponds to the:
(A) Rotational or vibrational energy state transitions of the molecule
(B) Kinetic energy of the ejected electron
(C) Nuclear magnetic resonance frequency
(D) Ionization energy of the molecule

(A) A highly destructive mobile phase
(B) Broad, poorly resolved peaks
(C) Very low retention times
(D) Narrow, sharp peaks indicating high efficiency

2005
205. Which carrier gas is most commonly utilized with a Flame Ionization Detector (FID) in GC to provide the best balance of safety, cost, and efficiency?
(A) Helium or Nitrogen
(B) Oxygen
(C) Acetylene
(D) Carbon dioxide

2011
206. High-Performance Liquid Chromatography (HPLC) columns are typically packed with uniformly sized micro-particles. What is the primary physical consequence of decreasing the particle size?
(A) Drastically lower required operating pressure
(B) Decreased resolution and increased band broadening
(C) Increased column efficiency accompanied by higher backpressure
(D) Inability to perform gradient elution

2005
207. Which HPLC detector measures a bulk property of the eluent and is notoriously sensitive to changes in mobile phase temperature and composition?
(A) Refractive Index (RI) Detector
(B) UV-Vis Diode Array Detector
(C) Fluorescence Detector
(D) Electrochemical Detector

2024
208. In NMR spectroscopy, the process of Fourier Transformation is applied to convert the measured Free Induction Decay (FID) signal from the:
(A) Time domain to the frequency domain
(B) Frequency domain to the time domain
(C) Mass-to-charge ratio to molecular weight
(D) Absorbance spectrum to a transmittance spectrum

2010
209. Which mass spectrometer analyzer separates ions by projecting them down a flight tube and measuring the time taken to reach the detector?
(A) Quadrupole
(B) Ion Trap
(C) Time-of-Flight (TOF)
(D) Magnetic Sector

2024
210. In ESR spectroscopy, the sample is placed in a microwave cavity and subjected to a varying magnetic field. Resonance occurs when the applied magnetic field matches the:
(A) Larmor precessional frequency of nearby protons
(B) Total kinetic energy of the active free radical
(C) Energy gap between split electron spin states
(D) Minimum ionization potential of the target molecule

2025
211. In industrial flue gas monitoring, a Katharometer is primarily used to detect variations in the:
(A) Opacity of the gas stream
(B) UV absorbance of sulfur compounds
(C) Thermal conductivity of the gas mixture
(D) Chemiluminescence of nitrogen oxides

2006
212. The magnetic susceptibility of oxygen is highly positive (paramagnetic), while most other common gases in air (like N_2 and CO_2) are:
(A) Also highly paramagnetic
(B) Ferromagnetic
(C) Diamagnetic
(D) Superconducting

2025
213. Industrial monitoring of NO and NO_2 (NO_x) using chemiluminescence relies on the reaction of NO with which specific gaseous reagent?
(A) Hydrogen gas
(B) Ozone
(C) Carbon monoxide
(D) Chlorine gas

2024
214. Which region of the gas-filled detector voltage curve represents the condition where collection of primary ions occurs without any secondary gas multiplication?
(A) Recombination region
(B) Ionization chamber region
(C) Proportional region
(D) Geiger-Muller region

2023
215. Semiconductor radiation detectors, such as HPGe, are analogous in operation to which electronic component functioning under a reverse bias?

NODIA

2012

193. The internal reference electrode in a standard glass pH electrode is typically composed of:
(A) Silver/Silver Chloride (Ag/AgCl) junction
(B) A solid, high-purity block of pure copper
(C) A highly polished dropping mercury capillary
(D) Platinum wire in a hydrogen gas atmosphere

2007

194. The cell constant of a conductivity probe requires calibration using a standard solution of known conductivity. Which substance is universally accepted for this purpose?
(A) High-purity deionized water
(B) Dilute hydrochloric acid (HCl)
(C) Standard potassium chloride (KCl)
(D) Concentrated sodium hydroxide (NaOH)

2025

195. In classical polarography, the dropping mercury electrode (DME) provides a highly reproducible current-voltage curve because:
(A) Mercury is inert and does not oxidize
(B) It operates at extremely high positive potentials
(C) The electrode surface is continuously renewed, preventing surface fouling
(D) It employs a solid, static planar surface

2011

196. Specific ion meters measure the concentration of ions using an ion-selective electrode (ISE) coupled with a reference electrode. The measured voltage is proportional to the:
(A) Logarithm of the ion's activity
(B) Inverse of the ion's concentration
(C) Direct linear concentration of the ion
(D) Square of the ion's activity

2013

197. According to the Beer-Lambert law, if the absorbance of a solution is zero, the percent transmittance is:
(A) 0%
(B) 10%
(C) 50%
(D) 100%

2022

198. Which component is strictly necessary in a double-beam UV-Vis spectrophotometer but absent in a single-beam configuration?
(A) A quartz cuvette for the sample
(B) A high-sensitivity photodetector
(C) An optical beam splitter
(D) A stable broadband light source

2013

199. The Globar source used in IR spectroscopy is primarily composed of:
(A) A hollow cathode containing noble gases
(B) Silicon carbide heated electrically
(C) A tungsten filament in a halogen atmosphere
(D) A high-pressure xenon arc

2018

200. In Raman spectroscopy, because Raman scattering is an extremely weak effect, which of the following is essential for modern instrumentation?
(A) Low-intensity incandescent bulb source
(B) An intense monochromatic light source, typically a laser
(C) A thick lead shield around the sample compartment
(D) Operation under high vacuum

2023

201. Flame emission spectrophotometry is most widely and successfully used for the routine quantitative analysis of:
(A) Noble gases
(B) High molecular weight proteins
(C) Alkali metals (e.g., Sodium, Potassium)
(D) Halogens

2004

202. In Atomic Absorption Spectrophotometry, background correction using a Deuterium continuum source works by:
(A) Measuring total absorbance and background absorbance alternately and subtracting the background
(B) Utilizing a magnetic field to split the analyte absorption line (Zeeman effect)
(C) Physically removing the background matrix from the sample before atomization
(D) Adding a chemical releasing agent

2017

203. The primary detector utilized in ICP-AES systems to capture simultaneous multi-element emission spectra is the:
(A) Hollow Cathode Lamp
(B) Charge-Coupled Device (CCD) or similar array detector
(C) Geiger-Muller tube
(D) Evaporative Light Scattering Detector

2001

204. In chromatography, the theoretical plate count (N) is a measure of column efficiency. A high N value corresponds to:

Downloaded from www.pdf.tube

2001

226. In Flame Emission Spectrophotometry, the intensity of the emitted light is directly proportional to the:
(A) Square root of the analyte concentration
(B) Direct concentration of the analyte in the sample
(C) Logarithm of the analyte concentration
(D) Inverse of the analyte concentration

2014

227. A chemical interference in AAS caused by the formation of calcium phosphate in the flame can be mitigated by adding an excess of Lanthanum. In this context, Lanthanum acts as a:
(A) Releasing agent
(B) Matrix modifier
(C) Radiation buffer
(D) Ionization suppressant

2018

228. Inductively Coupled Plasma (ICP) sources require continuous cooling to prevent the melting of the quartz torch. This is achieved by:
(A) Immersing the torch in a liquid nitrogen bath
(B) Passing a high flow rate of tangential cooling argon gas along the inner walls of the torch
(C) Utilizing a completely ceramic torch structure
(D) Cycling the RF power on and off rapidly

2010

229. In a chromatogram, the time elapsed from sample injection to the appearance of the maximum peak of the non-retained solvent is known as the:
(A) Adjusted retention time
(B) Dead time (or void time)
(C) Peak width at half height
(D) Resolution time

2011

230. Electron Capture Detectors (ECD) in GC are extraordinarily sensitive to:
(A) Saturated linear hydrocarbons
(B) Electronegative functional groups, such as halogens
(C) Noble gases
(D) Simple aliphatic alcohols

2001

231. In HPLC, a "gradient" method is often superior to an "isocratic" method because it:
(A) Keeps the solvent viscosity constant
(B) Dramatically decreases the total analysis time for samples with widely varying polarities
(C) Eliminates the need for a high-pressure pump
(D) Allows the use of a simple Refractive Index detector

2002

232. An Evaporative Light Scattering Detector (ELSD) is particularly useful in HPLC for detecting analytes that:
(A) Possess strong UV chromophores
(B) Are highly volatile gases at room temperature
(C) Lack a UV chromophore but are less volatile than the mobile phase
(D) Fluoresce naturally

2013

233. The chemical shift of a proton in NMR spectroscopy is highly dependent upon its:
(A) Local electronic environment (shielding/deshielding effects)
(B) Distance from the center of the sample tube
(C) Atomic mass number
(D) Spin quantum number

2023

234. In Electrospray Ionization (ESI) Mass Spectrometry, the analyte solution is forced through a capillary held at a high voltage, producing a fine mist of highly charged droplets. As the solvent evaporates, what happens?
(A) The droplets freeze rapidly into solid crystalline particles
(B) The sample neutralizes and forms a precipitate
(C) Droplets undergo coulombic fission to form gas-phase ions
(D) The sample absorbs intense ultraviolet light and decomposes

NODIA

2013

235. Electron Spin Resonance (ESR) is practically synonymous with:
(A) Electron Paramagnetic Resonance (EPR)
(B) Nuclear Magnetic Resonance (NMR)
(C) X-ray Photoelectron Spectroscopy (XPS)
(D) Electron Capture Detection (ECD)

2018

236. A Katharometer bridge circuit for thermal conductivity analysis typically utilizes filaments constructed from a material with a high temperature coefficient of resistance, such as:
(A) Lead or Tin
(B) Copper or Aluminum
(C) Platinum or Tungsten

(D) Carbon fiber

2010

237. The Zirconium oxide oxygen sensor essentially functions as a solid-state:
(A) Electrolytic plating bath system
(B) Galvanic concentration cell
(C) Magnetic sector mass analyzer
(D) Diffraction optical grating

2005

238. In NDIR (Non-Dispersive Infrared) analysis for industrial emissions, what replaces the monochromator found in standard dispersive IR spectrometers?
(A) A variable pathlength flow cell
(B) A diffraction grating
(C) An optical bandpass filter specific to the target gas's absorption wavelength
(D) A Fourier Transform interferometer

2016

239. The Townsend avalanche in a proportional counter differs from that in a GM counter because in the proportional counter, the avalanche is:
(A) Suppressed by the quenching gas
(B) Localized near the primary ionization event, allowing pulse height to remain proportional to primary energy
(C) Spread across the entire length of the anode wire
(D) Created strictly by photoelectric emission from the cathode walls

2018

240. Gamma Spectrometry utilizing a NaI(Tl) scintillation detector typically yields a spectrum showing a distinct:
(A) Continuous baseline with no recognizable peaks
(B) Single sharp peak for all isotopes regardless of energy
(C) Series of strictly equidistant peaks
(D) Photopeak corresponding to the full energy of the gamma ray, along with a Compton continuum

2003

241. Thermogravimetric Analysis (TGA) provides continuous measurement of sample mass as temperature is varied. Which of the following phenomena CANNOT be detected by TGA?
(A) Loss of water of hydration
(B) Thermal decomposition to gas
(C) Metal oxidation with mass gain
(D) Melting without mass change

2006

242. Standard reference electrodes, such as the SCE, maintain a constant potential because:
(A) They are physically isolated from the surrounding environment
(B) They undergo specialized chemical reactions without any net charge
(C) The internal electrolyte concentration is kept constant
(D) They employ pure water as their internal filling solution

2002

243. The "asymmetry potential" of a glass pH electrode refers to the small potential difference that exists even when:
(A) The electrode is broken or physically damaged in some way
(B) Identical solutions face both sides of the glass membrane
(C) The electrode is immersed in a solution of pH 0
(D) The operating temperature reaches exactly 100 degrees Celsius

2012

244. In conductivity measurements, alternating current (AC) is applied to the Wheatstone bridge circuit. If the frequency of the AC is too low, what analytical error may occur?
(A) The water will begin to boil
(B) The cell will act as a perfect insulator
(C) Faradaic polarization of the electrodes may occur, altering the measured resistance
(D) The glass cell will fracture due to acoustic resonance

2015

245. In polarography, the half-wave potential ($E_{\frac{1}{2}}$) is functionally significant because it:
(A) Is directly proportional to the concentration of the analyte
(B) Indicates the exact volume of the mercury drop
(C) Is characteristic of the specific electroactive species, providing qualitative information
(D) Measures the resistance of the capillary tube

2006

246. Specific ion meters can experience interference from other ions in solution. The sensitivity of an ion-selective electrode is mathematically described by the:
(A) Ilkovic coefficient parameter
(B) Nernst-Planck flux equation
(C) Nicolsky-Eisenman equation

Click Here to Buy book on Amazon

(D) Kohlrausch empirical constant

2011

247. The Beer-Lambert law assumes that the incident radiation is:
(A) Monochromatic
(B) Polychromatic
(C) Unpolarized
(D) Diffusely scattered

2022

248. A double beam in-space UV-Vis spectrophotometer operates by:
(A) Using a spinning chopper mirror to alternate the beam between sample and reference
(B) Utilizing a beam splitter to pass light simultaneously through both sample and reference cells to two matched detectors
(C) Physically moving the single detector back and forth
(D) Scanning two different wavelengths sequentially

2017

249. In FTIR spectroscopy, the He-Ne laser is utilized primarily to:
(A) Heat the sample to its vaporization temperature
(B) Track mirror position and calibrate wavelengths
(C) Provide continuous infrared radiation for absorption
(D) Eliminate carbon dioxide gas from the optical path

2004

250. Raman scattering is intrinsically a very weak phenomenon. Approximately what fraction of the incident photons undergo Raman scattering?
(A) 1 in 10
(B) 1 in 100
(C) 1 in 10,000
(D) 1 in 1,000,000 to 10,000,000

2014

251. The purpose of the nebulizer in a Flame Emission Spectrophotometer is to:
(A) Convert the liquid sample into a fine aerosol mist for introduction into the flame
(B) Excite the atoms using electrical energy
(C) Burn off the organic matrix prior to injection
(D) Separate the wavelengths of emitted light

2014

252. The hollow cathode lamp used in AAS emits the spectral lines of:
(A) The deuterium continuum
(B) The carrier gas
(C) The specific element that comprises the cathode material
(D) All elements simultaneously

2011

253. In an ICP torch, the magnetic field that induces the alternating current in the argon plasma is generated by a:
(A) High-voltage direct current grid
(B) Permanent neodymium magnet
(C) Radio-frequency induction coil surrounding the torch
(D) Microwave cavity oscillator

NODIA

2011

254. The van Deemter equation models column efficiency. Which term in the equation is directly proportional to the linear velocity of the mobile phase?
(A) The Eddy diffusion term (A)
(B) The Longitudinal diffusion term (B)
(C) The Resistance to mass transfer term (C)
(D) The partition coefficient (K)

2014

255. In Gas Chromatography, varying the column temperature during a run is known as temperature programming. This technique is applied to:
(A) Protect the detector from overheating
(B) Keep the carrier gas flow constant
(C) Improve the separation of components with a wide range of boiling points, reducing total run time
(D) Allow the use of a shorter capillary column

2004

256. A monolithic HPLC column differs from a traditional packed column because it contains:
(A) Completely inert metal particles
(B) A single continuous piece of porous material rather than individual packed particles
(C) Only a single massive theoretical plate
(D) A liquid stationary phase bound to no solid support

2008

257. Which characteristic makes the Refractive Index (RI) detector difficult to use with gradient elution in HPLC?
(A) Its continuous requirement for a matched reference flow makes baseline stabilization impossible as solvent composition changes
(B) It rapidly destroys any non-polar analytes
(C) It only functions with completely transparent

mobile phases
(D) It requires the mobile phase to be heated to boiling

2015
258. The Larmor frequency of a nucleus in an NMR spectrometer increases linearly as the:
(A) Operating temperature of the sample increases
(B) Spin-lattice relaxation time of the nuclei decreases
(C) Applied external magnetic field (B_0) increases
(D) Overall dynamic viscosity of the solvent increases

2012
259. The Time-of-Flight (TOF) mass analyzer is highly advantageous for biological macromolecules primarily because it:
(A) Has a theoretically unlimited upper mass range
(B) Operates without requiring any high vacuum
(C) Is the smallest and most portable mass analyzer
(D) Completely suppresses unwanted isotopic peaks

2015
260. A standard for measuring the g-factor in ESR spectroscopy is DPPH. DPPH is chemically classified as a:
(A) Stable organic free radical
(B) Transition metal coordination complex
(C) Semiconductor nanocrystal
(D) Polycyclic aromatic hydrocarbon

2008
261. In the context of industrial flue gas analysis, unburned combustibles often indicate:
(A) Optimal burner tuning
(B) Excess air levels exceeding 50%
(C) Fuel-rich combustion conditions or poor burner mixing
(D) Extremely low stack temperatures

2015
262. Which oxygen analyzer technology is most suitable for high-temperature in-situ measurement directly within a combustion stack?
(A) Paramagnetic dumbbell sensor
(B) Heated Zirconium oxide sensor
(C) Electrochemical Clark cell
(D) NDIR optical sensor

2018
263. Non-Dispersive Infrared (NDIR) technology is considered "non-dispersive" because:
(A) It relies on the emission of light rather than absorption
(B) It does not disperse the sample gas into the atmosphere
(C) It passes broadband infrared light through the sample without separating it into a continuous spectrum using a prism or grating
(D) It only detects solid particulate matter dispersed in the gas

2006
264. The primary ionization event in a gas-filled detector generates an ion pair consisting of:
(A) An alpha particle and a beta particle
(B) A positive gas ion and a free electron
(C) Two neutral atoms
(D) A photon and a phonon

2023
265. Solid-state semiconductor detectors require ultra-high purity materials (like HPGe) because impurities act as:
(A) Trapping centers for charge carriers, degrading the energy resolution
(B) Lenses that scatter gamma rays
(C) Amplifiers for background thermal noise
(D) Insulators that prevent the application of bias voltage

2017
266. A typical TGA curve provides information primarily on:
(A) Thermal stability and compositional fraction of volatile components
(B) The exact crystalline structure of the material
(C) The precise molecular weight of the compound
(D) The specific heat capacity at constant volume

2008
267. When constructing an electrochemical cell, the reference electrode is typically designated as the:
(A) Anode chamber where oxidation reactions primarily occur
(B) Cathode chamber where reduction reactions primarily occur
(C) Salt bridge connecting the two electrolyte solutions
(D) Half-cell against which the indicator is measured

Downloaded from www.pdf.tube

2021

268. A pH meter converts the measured potential difference (in millivolts) into a pH reading. At 25°C, a change of 1 pH unit corresponds to a potential change of approximately:
(A) 1.0 mV
(B) 10.0 mV
(C) 59.16 mV
(D) 100.0 mV

2019

269. The equivalent conductance of a strong electrolyte increases with dilution primarily because:
(A) Interionic attractions (retardation forces) decrease as ions move further apart
(B) The degree of ionization increases
(C) The solvent viscosity increases
(D) The cell constant changes with concentration

2018

270. In specific ion analysis, the potential developed across a fluoride-selective crystalline membrane is a result of:
(A) The reduction of fluoride ions to fluorine gas at the interface
(B) The migration of europium ions completely through the crystal lattice
(C) The unequal distribution and exchange of fluoride ions across the phase boundary between the crystal and the solution
(D) The physical pressure of the solution against the membrane

****

NODIA

ANSWERS

1. (B) Nernst equation
The electrochemical cell potential depends on the concentration of the electroactive species in solution. This relationship is mathematically described by expressing the electrode potential as a function of the standard potential, temperature, and reaction quotient. It allows the determination of solute activity and concentration through potentiometric measurements under non-standard conditions.

2. (C) To compensate for the temperature-dependent change in the Nernstian slope of the electrode
Electrode potentials are temperature-dependent as defined by the Nernst equation, where the slope of the response curve changes with temperature. The automatic temperature compensation system measures the sample temperature and mathematically adjusts the calibration slope of the instrument. This ensures accurate hydrogen ion concentration readings regardless of thermal variations during analysis.

3. (C) A is true but R is false.
The independent migration of ions occurs when electrolyte solutions are diluted to the limit where solute molecules dissociate completely. At this infinite dilution, interionic interactions become negligible, allowing each ion to contribute independently to conductivity. Therefore, asserting that migration is independent is true, whereas stating that interionic interactions are maximized at infinite dilution is false.

4. (D) To selectively allow the diffusion of oxygen while blocking interferences
An electrochemical cell designed to measure dissolved oxygen requires protection from ionic species and other potential interferents in the sample. The semipermeable membrane acts as a physical barrier that selectively allows oxygen gas molecules to diffuse through to the cathode. This selective diffusion ensures that the measured reduction current corresponds accurately to oxygen concentration.

5. (A) Colorimetric heteropoly blue method
Trace analysis of dissolved silica in industrial water systems utilizes chemical reaction pathways to produce a measurable colored compound. Silica reacts with molybdate under acidic conditions to form silicomolybdic acid, which is subsequently reduced to an intense blue complex. Measuring the light absorbance of this heteropoly blue complex allows precise determination of low silica concentrations.

6. (D) Electrostatic interactions between closely packed solute species
Absorbing species in highly concentrated solutions experience close proximity to one another, leading to significant electrostatic interactions and charge distribution alterations. These interionic or intermolecular forces modify the transition energy states and the molar absorptivity of the analyte, causing a non-linear relationship between absorbance and concentration. This chemical phenomenon represents a fundamental deviation from ideal absorption behavior.

7. (B) P-4, Q-3, R-1, S-2
Spectrophotometric analysis relies on specialized optical and electrical components to generate and measure light. The deuterium lamp provides continuous ultraviolet radiation, while the monochromator isolates specific wavelengths from the source. The photomultiplier tube amplifies low-intensity optical signals, converting them to electrical currents, and double-beam optics correct for any fluctuations in source intensity during measurements.

8. (C) Resistance heating of a rare-earth oxide ceramic rod
Infrared spectroscopy requires a stable continuous radiation source to probe molecular vibrations. The Nernst glower consists of a cylindrical rod fabricated from a mixture of rare-earth oxides, such as zirconium, yttrium, and thorium. Passing an electrical current through this ceramic material heats it resistively to high temperatures, causing it to emit intense infrared radiation.

Click Here to Buy book on Flipkart

9. (D) Lower energy than the incident photons
Inelastic scattering of monochromatic light involves energy transfer between incident photons and molecular vibrational states. When the molecule absorbs energy from the incoming light to transition to an excited vibrational level, the scattered photon is released with reduced kinetic energy. This shift to lower frequencies and longer wavelengths produces the characteristic Stokes lines in spectral profiles.

10. (C) The interzonal region
An analytical flame is divided into distinct zones with unique thermal and chemical profiles. The interzonal region, situated between the primary combustion and secondary combustion zones, is the hottest part of the flame. This high temperature provides optimal conditions for desolvation, vaporization, and atomization of the aspirated sample, maximizing the population of free ground-state atoms.

11. (A) I and III
Chemical interferences occur when target analyte atoms react with anions in the sample matrix, creating thermally stable, refractory compounds that resist atomization. Adding a releasing agent like lanthanum preferentially binds to these anions, freeing the analyte. Spectral interference involves overlapping absorption or emission bands and is not solved by simply changing flame temperatures, making statement II incorrect.

12. (B) ICP provides an inert argon environment that minimizes oxide formation
Inductively coupled plasma utilizes radiofrequency energy to ionize argon gas, creating an extremely hot, chemically inert environment. Unlike combustion flames that contain highly reactive oxygen-containing radicals, the argon plasma prevents the formation of refractory oxides of the analyte. This chemically clean excitation source enhances sensitivity, improves detection limits, and drastically minimizes chemical interferences during elemental analysis.

13. (B) $R = \dfrac{2\,(t_{R2} - t_{R1})}{w_1 + w_2}$
Chromatographic resolution quantifies the degree of separation between two adjacent eluting bands. It is mathematically calculated by dividing twice the difference in retention times of the two peaks by the sum of their baseline peak widths. This calculation ensures that both the peak migration rates and the peak dispersion characteristics are taken into account for assessment.

14. (C) Halogenated organic compounds
The electron capture detector operates by measuring the decrease in standing current as elective species capture thermal electrons. Compounds containing highly electronegative atoms, particularly halogens such as chlorine, bromine, and fluorine, possess a high affinity for electrons. This makes the detector exceptionally sensitive to halogenated organic compounds, such as pesticides, and relatively insensitive to hydrocarbons.

15. (B) II only
Reversed-phase liquid chromatography pairs a non-polar stationary phase with a polar mobile phase, while normal-phase utilizes a polar stationary phase. Isocratic elution is defined by maintaining a constant mobile phase composition throughout the separation process, meaning statement II is incorrect. Conversely, gradient elution continuously alters solvent strength over time to accelerate the elution of strongly retained analytes.

16. (C) Refractive Index (RI) detector
A bulk property detector measures changes in a physical property of the combined mobile phase and solute rather than a specific solute characteristic. The refractive index detector monitors the difference in refractive index between the column effluent and a reference stream of pure mobile phase. This universal detection method responds to any substance that alters the overall refractive index.

17. (A) Precessional frequency of the magnetic moment of a nucleus
When atomic nuclei possessing a non-zero magnetic spin are placed inside an external magnetic field, they precess around the field axis. The precessional frequency of this nuclear magnetic moment is directly proportional to the applied magnetic field strength. This frequency is referred to as the Larmor frequency, representing the exact radiofrequency required to induce nuclear resonance.

18. (D) Matrix-Assisted Laser Desorption Ionization (MALDI)
Large biomolecules such as proteins and polymers are prone to thermal degradation and severe

Downloaded from www.pdf.tube

fragmentation under high-energy ionization conditions. Matrix-assisted laser desorption ionization embeds the analyte in a crystalline organic matrix that absorbs laser energy, facilitating gentle desorption and ionization. This soft ionization preserves the intact molecular ion, allowing precise mass determination of fragile, high-mass compounds.

19. (C) I, II and IV
Electron spin resonance spectroscopy relies on detecting transitions of unpaired electrons in a magnetic field, which splits degenerate spin states via the Zeeman effect. The g-factor is sensitive to local chemical environments, making statement III incorrect, while spectral transitions occur in the microwave region, making statement V incorrect. Thus, only statements I, II, and IV are correct.

20. (A) Differential thermal conductivity between the sample gas and a reference gas
Continuous flue gas monitoring often utilizes a Katharometer, which operates on the principle that different gases conduct heat at varying rates. The sensor compares the rate of heat loss from electrically heated filaments exposed to the sample gas against filaments in a reference gas. This temperature differential imbalances a Wheatstone bridge, producing a signal proportional to gas concentration.

21. (B) Zirconium oxide stabilized with yttria
High-temperature electrochemical oxygen sensors rely on solid state materials that can selectively conduct ions under high thermal conditions. Zirconium oxide stabilized with yttria creates oxygen vacancy defects within the crystal lattice structure. At temperatures exceeding several hundred degrees Celsius, these vacancies facilitate the rapid mobility of oxide ions, serving as an efficient solid-state electrolyte.

22. (D) Chemiluminescence with ozone
Continuous monitoring of nitrogen oxides is achieved by reacting nitric oxide with excess ozone in a reaction chamber. This gas-phase reaction produces nitrogen dioxide molecules in an electronically excited state. As these excited molecules decay to the electronic ground state, they emit characteristic light, which is subsequently measured using a sensitive photomultiplier tube detection system.

NODIA

23. (A) Recombination region, Ionization region, Proportional region, Geiger-Muller region
Gas-filled radiation detectors operate by collecting ions generated in an internal chamber. As the bias voltage across the electrodes increases, the detector traverses distinct operational regions. Starting at low voltages, the sequence progresses through recombination of ions, then the ionization chamber region, followed by the gas-amplified proportional region, and finally the saturated Geiger-Muller region.

24. (C) Superior energy resolution
Semiconductor detectors, such as high-purity germanium, generate a significantly larger number of charge carriers per unit of absorbed radiation energy compared to scintillation crystals. This reduces statistical fluctuations in the electrical signal produced by the detector. Consequently, these solid-state sensors provide vastly superior energy resolution, allowing close-lying energy peaks to be resolved cleanly in gamma spectra.

25. (D) Rate of mass change ($\frac{dm}{dt}$)

Thermogravimetric techniques monitor sample mass variations in response to controlled heating. In the derivative mode of this analysis, the mathematical derivative of the mass-change curve with respect to temperature or time is calculated. Plotting this rate of mass change on the vertical axis yields sharp peaks that clearly identify the precise temperatures of thermal decomposition events.

26. (A) Saturated Calomel Electrode
Electroanalytical measurements require a reference electrode with a highly stable and reproducible potential. The saturated calomel electrode, based on the reaction between elemental mercury and mercury chloride in a saturated potassium chloride solution, is simple to prepare and maintains a robust potential. Its physical convenience makes it far more practical for routine laboratory use than standard hydrogen electrodes.

27. (A) III, IV, II, I
Calibration of a glass pH electrode begins by determining the zero-point asymmetry potential. This is done by submerging the rinsed electrode into a neutral pH 7.00 buffer and adjusting the baseline. Following this, the electrode is rinsed

with water to prevent cross-contamination, and then placed in an acidic or alkaline buffer to adjust the response slope.

28. (B) The distance between electrodes divided by their cross-sectional area
The cell constant is a fundamental geometric factor that relates measured electrical resistance to the specific conductivity of an electrolyte. It is mathematically defined as the ratio of the distance separating the two parallel electrode plates to the active cross-sectional area of those plates. This constant is crucial for converting conductance measurements into absolute conductivity values.

29. (A) Polarization at the electrodes
Measuring the electrical conductance of solutions with direct current induces electrolysis at the electrode surfaces, leading to the accumulation of chemical species and gas bubbles. This polarization creates an additional electrical resistance that distorts measurements. Using an alternating current continually reverses the direction of ion movement, successfully preventing electrode polarization and ensuring accurate resistance determinations.

30. (B) Ilkovic equation
The limiting diffusion current observed at a dropping mercury electrode is governed by mass transport rates and mercury drop geometry. This relationship is mathematically formulated through the Ilkovic equation, which incorporates parameters such as the diffusion coefficient, analyte concentration, mercury flow rate, and drop lifetime. It forms the quantitative basis for all polarographic concentration determinations.

31. (C) A is true but R is false.
Sodium ion-selective electrodes utilize specialized aluminosilicate glass membranes that selectively coordinate with sodium ions to establish a membrane potential. While these glass formulations are highly selective for sodium, they are not completely impervious to other monovalent cations, as hydrogen and potassium ions can still act as interferents. Therefore, the assertion is correct, but the reason is false.

32. (C) Negative deviations from Beer's Law at high concentrations
Stray light consists of radiation reaching the detector that has not passed through the sample at the selected analytical wavelength. At high concentrations, where the sample absorbs nearly all primary light, stray light becomes a significant portion of the total transmitted energy detected. This artificially increases the transmitted signal, causing negative deviations from linear absorbance behavior.

33. (D) Photodiode
Spectrophotometric analysis relies on converting optical energy that emerges from the sample cell into a measurable electronic signal. The photodiode is a solid-state semiconductor junction that generates a electrical current proportional to the intensity of the incident transmitted photons. This electrical output is then processed and recorded as either transmittance or absorbance values by the instrument.

34. (A) A moving mirror altering the optical path length
An interferometer splits a primary light beam into two distinct paths, reflecting them off a fixed mirror and a moving mirror. The continuous motion of this moving mirror introduces a changing optical path difference between the beams. When recombined, the light undergoes constructive and destructive interference, producing a time-dependent interferogram containing all spectral frequencies simultaneously.

35. (A) P-3, Q-2, R-4, S-1
Flame emission systems utilize specific configurations to introduce samples and support atomization. The premix burner mixes sample aerosol and gases prior to combustion, creating a quiet laminar flame, while a total consumption burner forces all aspirated liquid directly into the flame. The pre-heating zone initiates droplet desolvation, and the interzonal region hosts the highest population of free analyte atoms.

36. (B) To atomize the sample via intense electrical resistive heating
A graphite furnace serves as an electrothermal atomizer that replaces traditional gas-fed combustion burners. Passing high electrical currents through a hollow graphite tube generates intense resistive heating, rapidly raising the temperature in controlled steps. This thermal profile sequentially dries, ashes, and atomizes small volumes of liquid sample, producing a

Click Here to Buy book on Amazon

92. (B) Liquid junction potential
When two electrolyte solutions containing different concentrations or types of ions are brought into physical contact, the ions diffuse across the boundary at unequal rates. This differential mobility of cations and anions creates a localized charge separation at the interface. The resulting potential difference is referred to as the liquid junction potential, which must be minimized in accurate electrochemical measurements.

93. (D) Coating and fouling of the porous reference junction
Proteins in aqueous solutions tend to adsorb strongly onto physical surfaces and can precipitate when in contact with the concentrated potassium chloride electrolyte of the reference electrode. This leads to the coating and physical fouling of the porous reference junction. This blockage restricts electrical contact, leading to slow electrode response times, unstable readings, and significant measurement errors.

94. (A) Kohlrausch's law describing the independent migration of ions
Weak electrolytes do not dissociate completely at moderate concentrations, making it impossible to determine their limiting molar conductivity through direct extrapolation of experimental data. Instead, Kohlrausch's law of independent migration of ions is applied. This law states that at infinite dilution, ions contribute independently to total conductivity, allowing the value to be calculated from the limiting conductivities of individual strong electrolyte ions.

95. (D) Concentration of the electroactive species
The Ilkovic equation is a fundamental mathematical model that describes the current-potential-concentration relationships in polarographic experiments. It establishes that, under diffusion-controlled conditions at a dropping mercury electrode, the limiting diffusion current increases linearly with the concentration of the electroactive analyte in solution. This direct linear proportionality is what enables precise quantitative analysis in polarographic techniques.

96. (B) A sodium-selective glass electrode potentiometric system
High-purity industrial boiler systems require continuous, real-time monitoring of trace corrosive sodium ions to prevent boiler tube damage. A potentiometric system utilizing a specialized sodium-selective glass electrode offers the high sensitivity and selectivity required for this application. It detects sodium concentrations down to parts-per-billion levels under controlled, alkaline pH conditions that eliminate hydrogen ion interference.

97. (B) Instrumental deviation
The Beer-Lambert law strictly assumes that the incident radiation is completely monochromatic. When an instrument utilizes a wider spectral bandpass, the analyte exhibits different molar absorptivities across the selected wavelengths. This variation leads to non-linear calibration curves at elevated absorbances. Because this deviation arises from the physical limitations of the wavelength selector, it is classified as an instrumental deviation.

98. (D) Tungsten lamp
Spectrophotometers require distinct light sources to cover different regions of the electromagnetic spectrum. A tungsten-halogen or standard tungsten filament lamp is utilized to provide stable, continuous radiation across the visible and near-infrared regions, typically spanning from 350 to 2500 nanometers. Conversely, deuterium arc lamps are used to provide continuous radiation in the ultraviolet region.

NODIA

99. (C) Fixed distance and the other a continuously varying distance
The core of an FTIR spectrometer is the Michelson interferometer, which contains a beam splitter, a stationary mirror, and a moving mirror. One split beam travels a fixed distance to the stationary mirror, while the other travels a continuously varying distance to the moving mirror. Recombining these beams creates constructive and destructive interference, producing a detailed interferogram.

100. (B) $v_s < v_0$
In Raman spectroscopy, monochromatic incident laser light interacts with molecular vibrations, resulting in inelastic scattering. A Stokes shift occurs when the target molecule absorbs a portion of the incoming photon's energy, transferring it into a vibrational mode. Consequently, the scattered light is emitted at a lower frequency than the incident laser, meaning v_s is less than v_0.

46. (D) Linear quadrupole analyzer
Mass analyzers must selectively isolate ions of specific mass-to-charge ratios to generate a mass spectrum. The linear quadrupole analyzer consists of four parallel cylindrical metal rods placed in a symmetrical arrangement. Applying synchronized radiofrequency and direct current voltages to these rods creates an oscillating electric field that allows only ions with a targeted ratio to pass through.

47. (B) III and V
Electrospray ionization introduces liquid phase analytes directly at atmospheric pressure without requiring thermal vaporization, making statement III incorrect. Both electrospray and matrix-assisted laser desorption ionization are classic "soft" ionization methods that preserve intact molecular ions with minimal fragmentation, making statement V incorrect. Therefore, the incorrect statements are III and V.

48. (C) Lande g-factor
Paramagnetic species possess unpaired electrons whose energy levels split in the presence of an external magnetic field. The specific resonance condition is governed by a dimensionless parameter known as the Lande g-factor, which relates the magnetic moment of the electron to its spin angular momentum. This value acts as a characteristic marker for identifying various free radicals.

49. (C) Combustible gases such as methane and carbon monoxide
The energy content or calorific value of process and flue gases is directly determined by the presence of unburned combustible compounds. Gas analyzers measure the concentrations of species such as methane, carbon monoxide, and hydrogen that can undergo subsequent oxidation. Calculating the cumulative heat of combustion for these components yields a highly accurate real-time assessment of gas mixture calorific values.

50. (A) Temperature increases
Oxygen molecules exhibit strong paramagnetic properties due to their two unpaired electrons, which align parallel to an applied magnetic field. According to Curie's Law, this magnetic susceptibility is inversely proportional to the absolute temperature. As temperature increases, thermal agitation disrupts this alignment, thereby decreasing the overall paramagnetic susceptibility of the oxygen gas.

51. (B) Ion source, flight tube, reflectron, detector
In a time-of-flight mass spectrometer, ions are initially generated and accelerated within the ion source chamber. The accelerated ions then travel down a field-free drift region called the flight tube. A reflectron or ion mirror reverses their direction to correct for kinetic energy dispersions before the ions finally strike the detector surface to record arrival times.

52. (B) A broad-spectrum optical filter and reference gas cells
Non-dispersive infrared sensors do not utilize complex dispersive gratings or prisms to separate light into narrow wavelengths. Instead, they isolate target gas absorption bands using specific bandpass optical filters paired with reference and sample cells. Comparing the IR intensity transmitted through the sample cell to a reference cell containing non-absorbing gas allows highly selective determination of carbon monoxide concentrations.

53. (A) Excitation of SO_2 by UV light and measurement of subsequent fluorescent emission
Ambient sulfur dioxide monitoring utilizes the fluorescent properties of the molecule when exposed to ultraviolet radiation. The gas molecules absorb UV light at a specific excitation wavelength, promoting them to an unstable electronically excited state. As they return to the ground state, they emit longer-wavelength fluorescent light, the intensity of which is directly proportional to sulfur dioxide concentration.

54. (D) Prevent a continuous electrical discharge
During an ionizing event in a Geiger-Muller tube, a massive avalanche of secondary ions is produced. Positive ions striking the cathode can release secondary electrons, which would trigger subsequent, spurious avalanches and cause a continuous, self-sustaining electrical discharge. Quenching agents added to the fill gas absorb this excess energy, preventing continuous discharge and resetting the detector for subsequent pulses.

55. (B) II, III, IV, I
A scintillation counter operates through a sequence of energy conversions to detect nuclear radiation. First, incident gamma rays deposit

Downloaded from www.pdf.tube

energy within the sodium iodide crystal. This absorbed energy excites the crystal lattice, which subsequently emits visible light photons. These photons strike a photocathode to release photoelectrons, which are finally multiplied through dynode stages in a photomultiplier tube.

56. (B) It applies sufficient voltage to cause secondary ionization (Townsend avalanche)
Gas-filled radiation detectors are classified by the electric field strength applied between their electrodes. Unlike ionization chambers, which merely collect primary ions without amplification, proportional counters operate at significantly higher voltages. This elevated potential accelerates primary electrons to kinetic energies sufficient to cause secondary ionizations, initiating a localized Townsend avalanche that amplifies the electrical signal proportionally to energy.

57. (B) Difference in heat flow between a sample and a reference
Differential scanning calorimetry is a thermal analysis technique designed to investigate physical and chemical transitions in materials. The instrument subjects both a sample and an inert reference to a controlled temperature program while monitoring the thermal energy required. It measures the difference in heat flow to the sample and reference, yielding quantitative data on transition temperatures and enthalpies.

58. (A) Melting
Thermal transitions in polymer samples absorb or release specific amounts of heat. Melting is a thermodynamic phase transition where solid crystalline structures break down into a disordered liquid state. This process requires an input of thermal energy, manifesting as an endothermic peak on a differential scanning calorimetry curve. Conversely, crystallization is an exothermic process that releases heat.

59. (A) Both A and R are true and R is the correct explanation of A.
Determining absolute half-cell potentials is impossible without a standardized benchmark; therefore, electrochemical systems require a universal reference electrode. The standard hydrogen electrode, based on the reduction of hydrogen ions to hydrogen gas, is arbitrarily assigned a standard potential of exactly 0.00 V at all temperatures. This makes both the assertion and reasoning true, with the reasoning explaining the assignment.

NODIA

60. (B) A hydrated gel layer
The functioning of a glass membrane pH electrode is entirely dependent on chemical conditioning when exposed to aqueous solutions. Water molecules penetrate the silicate glass network, establishing a thin hydrated gel layer on both the outer and inner surfaces. This hydration allows ion exchange between sodium ions in the glass and hydrogen ions in solution, generating a measurable boundary potential.

61. (D) The electrode responds to high concentrations of alkali metal ions, particularly sodium.
At highly alkaline pH levels, the concentration of hydrogen ions in solution is extremely low. Under these conditions, the hydrated gel layer of a standard glass electrode begins to respond to other monovalent cations present in high concentrations, particularly sodium. This cation interference makes the measured pH appear lower than the actual value, a phenomenon known as alkaline error.

62. (C) Increases by about 2% per degree Celsius rise in temperature
The electrical conductivity of aqueous solutions is directly determined by the mobility of solvated ions. Rising temperatures decrease the viscosity of water and increase the kinetic energy of the ions, allowing them to migrate more rapidly in response to an electric field. This thermal physical change typically causes conductivity to rise by approximately two percent per degree Celsius.

63. (D) P-4, Q-3, R-1, S-2
Polarographic analysis depends on controlled electrochemical reactions at a dropping mercury electrode, which continuously renews the working surface. The half-wave potential serves as a qualitative characteristic value that identifies the specific electroactive species, while the Ilkovic equation quantitatively relates the diffusion current to concentration. Additionally, a supporting electrolyte is added to minimize migration currents of the electroactive species.

64. (B) Reduce oxygen to hydroxide ions
The Clark polarographic oxygen sensor operates by applying a constant polarization voltage between a platinum cathode and a silver anode.

This specific potential is chosen to be negative enough to drive the electrochemical reduction of oxygen diffusing through the membrane. Oxygen molecules are reduced to hydroxide ions at the cathode surface, generating a proportional current used for quantification.

65. (C) To maintain a constant background ionic strength, fixing the activity coefficient
Ion-selective electrodes respond directly to the thermodynamic activity of free ions rather than their total analytical concentration. Since activity depends on the overall ionic strength of the solution, variations in background ions can distort readings. Adding an ionic strength adjustment buffer establishes a high, constant background ionic strength, effectively locking the activity coefficient to ensure concentration-proportional potentials.

66. (B) Wavelength of the incident light beam
Molar absorptivity is an intrinsic physical constant that characterizes how strongly a chemical species absorbs light at a given frequency. Because molecular electronic transitions require discrete energy levels, the probability of light absorption varies dramatically across the optical spectrum. Consequently, molar absorptivity is highly dependent on the specific wavelength of the incident radiation used during analysis.

67. (A) I and II
Photomultiplier tubes achieve high sensitivity through an internal series of dynodes that amplify primary photoelectrons. Photodiodes lack this active internal gain mechanism, making them inherently less sensitive than photomultiplier tubes, which makes statements I and II correct. Diode array detectors feature thousands of pixels designed specifically to capture multiple wavelengths simultaneously, making statement III incorrect.

68. (D) Fluctuations in the radiant source intensity
Light sources, such as deuterium or tungsten lamps, suffer from drift and high-frequency intensity variations over time. Double-beam spectrophotometers split the light beam to pass through the sample and a reference blank simultaneously. Continuously ratioing these two signals cancels out any fluctuations in the radiant source intensity, ensuring stable, drift-free absorbance measurements.

69. (A) Time domain to the frequency domain
An FTIR spectrometer records raw intensity data as a function of the moving mirror's position, representing a time-dependent interference pattern. To extract a useful infrared spectrum, this raw interferogram must be translated into light intensity as a function of wavenumber. Applying a Fourier transform mathematically converts the data from the time domain to the frequency domain.

70. (A) Electrical resistance as a function of absorbed heat
Infrared radiation consists of low-energy photons that are generally insufficient to excite electronic transitions in solid-state semiconductor photodetectors. Instead, thermal detectors measure the heat deposited by the incoming IR beam. A bolometer consists of a temperature-sensitive element, such as a metal or semiconductor, whose electrical resistance changes measurably as it absorbs infrared thermal energy.

71. (D) III only
Rayleigh scattering represents elastic collisions where no energy is exchanged, while anti-Stokes scattering produces higher-energy photons from pre-excited molecules. Raman activity requires a change in molecular polarizability during vibration, not a permanent dipole moment, making statement III incorrect. Because Raman and infrared spectroscopies rely on different selection rules, they are complementary, leaving III as the only incorrect statement.

72. (A) Atomic Emission Spectrophotometry
Atomic emission spectroscopy involves introducing samples into a high-temperature excitation source, such as a flame or plasma, to atomize and excite the constituent elements. The thermally excited atoms rapidly return to lower energy states, emitting light at characteristic discrete wavelengths. Measuring the intensity of this emitted radiation provides a quantitative determination of the elemental concentrations.

73. (A) An inert gas like Neon or Argon at low pressure
Hollow cathode lamps generate the narrow emission lines of a target element required for atomic absorption. The sealed glass envelope contains a hollow cathode fabricated from the target metal, surrounded by an inert filler gas

Click Here to Buy book on Flipkart

highly concentrated cloud of free ground-state analyte atoms.

37. (B) A deuterium continuum lamp
Molecular species and smoke in the flame scatter light and introduce broad absorption interferences. A deuterium continuum lamp emits a broad spectrum of ultraviolet wavelengths that are absorbed by the background matrix but not significantly by the narrow-line atomic analyte. Subtracting the deuterium signal from the hollow cathode lamp signal isolates the true atomic absorption of the target analyte.

38. (D) Solid-state detector arrays (CCD or CID)
Simultaneous multi-element analysis requires detecting emission lines at numerous wavelengths across a wide optical spectrum. Modern inductively coupled plasma atomic emission instruments employ solid-state detector arrays, such as charge-coupled devices or charge-injection devices. These multi-channel sensors capture a complete two-dimensional spectral image, allowing rapid, highly sensitive, and simultaneous quantification of dozens of elements in a single sample run.

39. (C) I and III
Column efficiency in chromatography is directly related to the number of theoretical plates; therefore, a higher plate count indicates greater efficiency, making statement I incorrect. In gas chromatography, increasing the column temperature raises the analyte vapor pressure, causing it to spend less time in the stationary phase and decreasing its retention time, making statement III incorrect.

40. (A) Helium or Hydrogen
A thermal conductivity detector measures changes in heat dissipation as analytes pass over heated filaments. To maximize sensitivity, the carrier gas must possess a thermal conductivity that differs significantly from that of most organic analytes. Helium and hydrogen have exceptionally high thermal conductivities, ensuring a prominent electrical signal deviation when even trace amounts of sample molecules elute.

41. (D) Are open tubular columns with a coated inner wall
Capillary columns represent open tubular structures where the stationary phase is coated directly as a thin film on the inner wall. Unlike packed columns, they do not contain a granular solid support filling the tube. This elimination of packing material minimizes pressure drops, allowing the use of much longer columns that yield exceptionally high separation efficiencies.

42. (A) Elute earlier than a non-polar analyte
Reversed-phase high-performance liquid chromatography utilizes a non-polar stationary phase paired with a polar mobile phase. Solutes are separated based on their hydrophobic interactions with the stationary phase. Highly polar analytes have a strong affinity for the polar mobile phase and interact weakly with the non-polar surface, causing them to migrate rapidly and elute early from the column.

NODIA

43. (A) I, II and III
Reciprocating pumps provide high pressure and continuous flow but suffer from flow pulsations due to piston strokes. Syringe pumps deliver completely pulse-free flow, limited only by their cylinder volume. Pulse dampers are incorporated to smooth these flow fluctuations, whereas dual-piston pumps are widely used for gradient elution, making statement IV incorrect. Thus, only I, II, and III are correct.

44. (B) Can detect any analyte less volatile than the mobile phase
An evaporative light scattering detector operates by nebulizing the column effluent, evaporating the mobile phase, and measuring light scattered by the remaining solid analyte particles. It does not require a chromophore, making it a highly versatile detection system. The primary operational requirement is that the target analyte must be significantly less volatile than the surrounding solvent.

45. (D) Spin-spin coupling with adjacent non-equivalent nuclei
The magnetic moments of neighboring non-equivalent nuclei interact through intervening chemical bonds, causing mutual orientation alignments that affect local magnetic fields. This spin-spin coupling splits the primary resonance signal of a target nucleus into a multi-peak pattern or multiplet. This splitting pattern provides invaluable structural information regarding the exact connectivity and number of adjacent magnetic nuclei.

83. (A) P-2, Q-1, R-4, S-3
Mass spectrometry yields complex spectra characterized by several key features. The base peak represents the most intense signal, which is arbitrarily assigned a relative abundance of one hundred percent. The molecular ion peak corresponds to the unfragmented radical cation, while isotope peaks arise from heavier natural isotopes. These features are all resolved and plotted by their fundamental mass-to-charge ratio.

84. (B) Fourier Transform Ion Cyclotron Resonance (FT-ICR)
Fourier transform ion cyclotron resonance mass spectrometry achieves unparalleled resolution by utilizing strong superconducting magnetic fields to trap ions in circular cyclotron orbits. The orbiting ions generate a high-frequency image current on detector plates, which is recorded as a time-domain signal. Applying a Fourier transform yields exceptionally precise mass measurements, resolving isobaric species with extreme mass accuracy.

85. (A) Transient free radicals
Electron spin resonance spectroscopy, also known as electron paramagnetic resonance, specifically probes transitions of unpaired electron spins in a magnetic field. This quantum transition requirement makes the technique uniquely suited for detecting and characterizing transient free radicals, transition metal complexes, and other paramagnetic species. Conversely, closed-shell diamagnetic molecules do not exhibit any ESR absorption due to paired electron spins.

86. (A) Air or Nitrogen
Thermal conductivity detectors evaluate gas composition by measuring differences in heat dissipation rates. To obtain a stable baseline, the sample gas mixture is continuously compared against a reference gas of known, constant thermal properties. Air or pure nitrogen is typically selected as the reference because they are abundant, stable, and have well-defined thermal conductivities under standard operating conditions.

87. (A) Both A and R are true and R is the correct explanation of A.
Zirconia-based oxygen sensors operate as solid-state electrochemical cells that require mobile oxygen ions to generate a measurable Nernstian potential. At room temperature, the crystal lattice of yttria-stabilized zirconium oxide is rigid, restricting ion mobility. Heating the ceramic sensor to at least 600°C provides the thermal activation energy required to make it an effective ionic conductor.

NODIA

88. (C) Emits a photon on ground-state decay
Chemiluminescence detection is based on measuring light generated directly by a chemical reaction. When nitric oxide reacts with ozone, it produces nitrogen dioxide in an electronically excited state. As these high-energy molecules relax to their stable electronic ground state, they emit red and infrared photons. The intensity of this emitted light is directly proportional to nitric oxide concentration.

89. (D) Proportional to deposited radiation energy
In a gas-filled proportional counter, the applied voltage accelerates primary electrons to produce a localized avalanche of secondary ions. Unlike a Geiger-Muller tube, where the avalanche spreads along the entire anode to produce a saturated pulse, the proportional counter maintains a localized amplification. Consequently, the resulting electrical pulse amplitude remains directly proportional to the energy deposited by the incident radiation.

90. (B) Thallium (Tl)
Pure sodium iodide crystals are relatively inefficient scintillators at room temperature, releasing absorbed radiation energy as high-energy photons that are difficult to detect. Doping the crystal structure with trace amounts of thallium introduces localized activator states within the forbidden band gap. This modification significantly increases the probability of visible light emission, enhancing the overall detection efficiency of the system.

91. (B) P-3, Q-4, R-2, S-1
Thermal analysis techniques evaluate sample characteristics as a function of temperature. Thermogravimetric analysis tracks absolute mass changes, while derivative thermogravimetry calculates the rate of mass change over time. Differential scanning calorimetry measures the power required to maintain equal temperatures between sample and reference, whereas differential thermal analysis measures the actual temperature difference between them.

such as neon or argon at low pressure. Applying a high voltage ionizes this gas, initiating sputtering and subsequent excitation of the metal atoms.

74. (D) Chemical formation of refractory compounds resisting atomization
Chemical interferences represent the most common source of error in atomic absorption measurements. They occur when anions present in the sample react with the metal analyte to produce thermally stable, refractory compounds. These compounds do not fully dissociate at standard flame temperatures, reducing the population of free ground-state atoms available to absorb the incident light beam.

75. (A) I, II, III and V
Inductively coupled plasma systems employ radiofrequency energy to maintain an argon plasma seeded by an initial Tesla spark, with core temperatures exceeding 6,000 K. This extreme thermal energy ensures complete atomization, virtually eliminating chemical interferences. Because the plasma emits light from all elements simultaneously, it is excellent for multi-element analysis, making statement IV incorrect.

76. (B) Relative time spent in stationary and mobile phases
The capacity or retention factor is a dimensionless parameter that describes the migration rate of an analyte through a chromatographic column. It is mathematically calculated using the retention time of the solute relative to the void time of an unretained marker. This value reflects the relative distribution and time spent by the analyte between the stationary and mobile phases.

77. (C) Flame Ionization Detector (FID)
A flame ionization detector is highly sensitive to organic compounds eluting from a gas chromatography column. Operation requires mixing the column effluent with hydrogen and air, which is ignited to sustain a small, continuous flame. Hydrocarbons passing through this flame undergo thermal pyrolysis and ionization, producing ions that generate a measurable current between two internal collector electrodes.

78. (B) Non-polar to more polar
Normal-phase liquid chromatography pairs a highly polar stationary phase, such as silica, with a non-polar organic mobile phase. Highly polar analytes bind strongly to the polar surface, exhibiting long retention times. To accelerate their elution, a gradient program is used that gradually increases the polarity of the mobile phase over time, enhancing its ability to displace the polar analytes.

79. (C) A is true but R is false.
Normal-phase liquid chromatography utilizes a polar stationary phase, meaning non-polar solvents like hexane are ideal starting mobile phases because they exhibit weak interactions with the column. Polar analytes bind strongly to the polar silica, while hexane is easily displaced, allowing separation. Therefore, while the assertion is true, the reason is false because hexane does not bind strongly to polar silica.

80. (B) Chromophoric properties of the specific analytes
High-performance liquid chromatography detectors based on light absorption rely on the Beer-Lambert law, where response is proportional to molar absorptivity. The sensitivity of a UV-Vis detector is determined by how efficiently the target analyte absorbs light at the selected wavelength. This is a direct function of the molecular chromophores and conjugated electronic structures present within the analyte.

81. (C) Parts per million (ppm)
The exact resonant frequency of an active nucleus depends on its electronic environment and the strength of the external magnetic field. To ensure that chemical shift values remain independent of the specific spectrometer's magnetic field strength, they are expressed as a dimensionless ratio of frequency difference to operating frequency. This relative value is reported in parts per million.

82. (D) Tetramethylsilane (TMS)
Nuclear magnetic resonance requires an internal standard to establish a reliable zero-point reference for chemical shift scales. Tetramethylsilane is chosen because its twelve protons and four carbons are highly shielded, producing a single, sharp, intense resonance signal that occurs far upfield from almost all organic compounds. It is also chemically inert, volatile, and easily removed from samples.

Downloaded from www.pdf.tube

101. (C) Premix (laminar flow) burner
Flame emission spectroscopy requires a stable and quiet flame to minimize background signal fluctuations. The premix or laminar flow burner achieves this by mixing the aspirated sample aerosol, fuel, and oxidant within a chamber prior to combustion. This thorough pre-mixing produces a highly uniform, laminar flame that drastically reduces physical turbulence and optical noise during measurement.

102. (A) The atomic vapor resides in the optical path for a significantly longer time.
Flame atomization rapidly sweeps the atomized analyte out of the optical path, limiting the time available for light absorption. In contrast, electrothermal atomization in a graphite furnace traps the vaporized sample within a small, enclosed graphite tube. This significantly increases the residence time of the atomic vapor in the light path, dramatically enhancing the sensitivity and detection limits.

103. (D) Plasma
Inductively coupled plasma spectroscopy utilizes a high-energy gas phase composed of free electrons and positively charged argon ions. This state of highly ionized matter, sustained by radiofrequency induction, represents the plasma phase. The extreme temperatures achieved in this plasma state are highly efficient at desolvating, atomizing, and exciting elemental samples introduced into the core of the quartz torch.

104. (C) Resolution
Chromatographic resolution is a quantitative measure of the separation of two adjacent peaks on a chromatogram. It accounts for both the difference in their retention times and their physical peak widths at the baseline. Achieving a resolution of 1.5 or greater indicates complete baseline separation, ensuring that the individual components can be quantified accurately without peak overlap.

105. (D) Water
A flame ionization detector operates by measuring the electric current produced by the ionization of carbon atoms in a hydrogen-air flame. Since water does not contain carbon-hydrogen bonds and does not undergo carbon-pyrolysis to produce ions in the flame, it generates no response. This insensitivity makes the detector highly suitable for analyzing trace organic solutes in aqueous samples.

106. (B) Solvent composition remains constant throughout the run
Isocratic elution is an HPLC separation technique where the composition of the mobile phase is maintained constant from the beginning to the end of the run. This approach is highly effective for separating simple mixtures with similar retention behaviors. It provides exceptionally stable baselines and eliminates the column re-equilibration time required between consecutive gradient runs.

107. (C) It is incompatible with gradient elution.
A refractive index detector continuously monitors the overall refractive index of the eluting mobile phase. During gradient elution, the composition of the solvent changes continuously, which causes massive, uncontrolled drift in the baseline signal that completely obscures analyte peaks. Consequently, refractive index detectors are strictly restricted to isocratic separations, representing their primary operational disadvantage.

NODIA

108. (A) Significantly improved sensitivity and faster data acquisition via pulse techniques
Continuous wave NMR slowly sweeps frequencies or magnetic fields, which is slow and inefficient. In contrast, Fourier Transform NMR applies a short, intense radiofrequency pulse that excites all active nuclei simultaneously. The resulting free induction decay signal is captured rapidly in the time domain, allowing multiple scans to be accumulated quickly, greatly improving the signal-to-noise ratio.

109. (C) Mass-to-charge ratio ($\frac{m}{z}$)

A mass spectrometer operates by ionizing chemical species and manipulating their trajectories in electric or magnetic fields. The mass analyzer does not measure absolute molecular mass directly. Instead, it utilizes electrostatic, magnetic, or radiofrequency fields to separate and filter the accelerated ions based entirely upon their characteristic mass-to-charge ratio, directing them to the detector system.

110. (C) Unpaired electron spin
Electron spin resonance spectroscopy is a specialized analytical technique designed to study materials containing unpaired electrons.

183. (C) Number of equivalent adjacent NMR-active nuclei
In nuclear magnetic resonance spectroscopy, spin-spin splitting patterns provide detailed structural information about neighboring atoms. Under the traditional $n+1$ rule, the letter represents the number of equivalent adjacent NMR-active nuclei, such as protons, that are magnetically coupled to the nucleus under observation. This coupling splits the primary resonance peak into multiple symmetric sub-peaks.

184. (A) Absorb the laser energy and protect the biomolecule from direct destructive heating
In matrix-assisted laser desorption/ionization, the solid organic matrix plays a protective role during the ionization process. The matrix molecules absorb the intense ultraviolet energy from the laser pulse, preventing direct thermal damage to fragile biomolecules. This absorbed energy causes rapid sublimation of the matrix, carrying the intact analyte into the gas phase while facilitating proton transfer.

185. (C) 3
In electron spin resonance spectroscopy, the interaction between an unpaired electron and magnetic nuclei produces hyperfine splitting. The number of split lines is determined by the formula two times the number of nuclei times the nuclear spin, plus one. For a radical containing a single nitrogen-14 nucleus with a spin of one, this calculation yields three equally spaced lines.

186. (C) The combustion efficiency and air-to-fuel ratio
Monitoring the online calorific value of process gases is crucial for maintaining optimal operations in industrial furnaces and boilers. This measurement provides real-time data regarding the energy content of the fuel mixture, allowing control systems to precisely adjust the air-to-fuel ratio. Optimizing this ratio maximizes thermal combustion efficiency while minimizing the formation of hazardous emissions.

187. (B) The Nernst equation applied to a concentration cell
A high-temperature zirconium oxide oxygen sensor functions as a solid-state concentration cell. The ceramic zirconium membrane acts as a solid electrolyte that conducts oxygen ions. The difference in oxygen concentration between the reference air and the sample gas establishes an electromotive force across the membrane, which is quantitatively described by applying the Nernst equation.

188. (D) Sulfur dioxide (SO_2)
Sulfur dioxide is widely and reliably monitored in ambient air using ultraviolet fluorescence analyzers. When exposed to ultraviolet light of a specific wavelength, sulfur dioxide molecules absorb energy and transition to an excited state. Upon returning to their ground state, they emit fluorescent light at a longer wavelength, the intensity of which is proportional to concentration.

189. (B) Independent of the initial radiation type and energy
Operating a gas-filled detector in the Geiger-Muller region creates a very strong electric field that causes a localized avalanche to propagate along the entire length of the anode. Because of this complete gas ionization, the resulting output pulse reaches a saturated, maximum size. This makes the pulse amplitude independent of the original radiation type and energy.

190. (B) Converts light flashes into amplified electrical pulses
In a scintillation detector, the photomultiplier tube serves as the primary signal transducer. When incident ionizing radiation produces weak flashes of visible light within the scintillation crystal, these photons strike the photocathode of the tube. This releases photoelectrons, which are internally multiplied through a series of dynodes to generate a measurable, amplified electrical pulse.

191. (A) The temperatures of maximum rate of mass change
A derivative thermogravimetric curve represents the first derivative of the mass-change data with respect to time or temperature. Plotted peaks on this curve indicate the inflection points of the primary mass-loss steps. Consequently, these peak maxima correspond precisely to the temperatures at which the rate of chemical decomposition or vaporization is at its maximum absolute value.

192. (B) Nernst equation
The Nernst equation is a fundamental electrochemical relationship used to calculate the potential of an indicator electrode. This

Click Here to Buy book on Amazon

and faradaic polarization at the electrode-solution interface. Platinization deposits a thin layer of finely divided platinum black onto the solid platinum plates. This drastically increases the effective microscopic surface area of the electrodes, lowering the current density and successfully minimizing polarization errors during measurement.

120. (D) Oxygen is electroactive and produces two interfering reduction waves
Dissolved oxygen gas is highly electroactive at mercury electrodes and undergoes a two-step reduction process. It first reduces to hydrogen peroxide, which is subsequently reduced to water over a wide potential range. These resulting large reduction waves can overlap with and completely mask the signals of interest. Consequently, removing oxygen by purging with nitrogen is essential.

121. (A) Prevent hydrogen ion (H^+) interference at the glass membrane
Sodium-selective glass electrodes are susceptible to interference from hydrogen ions, which can easily exchange with the silicate network. To eliminate this interference, the pH of the sample must be raised to around 10 or higher. Adding an alkaline buffer, such as ammonia gas or dimethylamine, neutralizes hydrogen ions without introducing interfering sodium or other monovalent cations.

122. (B) $L \cdot mol^{-1} \cdot cm^{-1}$
According to the Beer-Lambert law, absorbance is a dimensionless quantity calculated as the product of molar absorptivity, concentration, and path length. To cancel out the units of concentration in moles per liter and path length in centimeters, molar absorptivity must have reciprocal units. This dictates that its unit is liters per mole per centimeter.

123. (B) Saturation
Under standard conditions, the population of ground-state molecules remains relatively constant during light absorption. However, when a sample is exposed to extremely high-intensity radiation, such as a focused laser beam, molecules are excited faster than they can relax. This temporarily depletes the ground-state population, reducing light absorption and causing a non-linear deviation known as saturation.

NODIA

124. (D) Reduce the artifactual side-lobes in the transformed spectrum caused by truncation of the interferogram
Because Michelson interferometers have a finite mirror travel distance, the recorded interferogram is abruptly truncated rather than measured to infinity. Applying a Fourier transform to this truncated signal generates artifactual side-lobes around spectral peaks. Apodization is a mathematical filtering process that multiplies the interferogram by a windowing function, successfully smoothing these truncation artifacts.

125. (B) Changes in the polarizability of the molecule during a vibration
Raman scattering is governed by the interaction between the electric field of incident laser light and the electron cloud of a molecule. For a molecular vibration to be Raman active, the shape or size of this electron cloud must deform during the vibration. The intensity of the resulting scattered light is proportional to this change in molecular polarizability.

126. (C) Fluctuations in the flame temperature
The population of excited-state atoms in a flame is extremely small and exponentially dependent on temperature, as described by the Boltzmann distribution. Consequently, even minor fluctuations in flame temperature can cause massive variations in the emitted light intensity. This makes flame emission spectroscopy far more susceptible to thermal instability compared to atomic absorption, which measures ground-state populations.

127. (B) Adding a releasing agent like Lanthanum or Strontium
Phosphate ions react with calcium to form calcium phosphate, a thermally stable compound that does not fully atomize in standard flames. To prevent this chemical interference, a releasing agent such as lanthanum or strontium is added to the sample. These metals preferentially bind with phosphate, freeing the calcium ions to be efficiently atomized in the flame.

128. (C) Undergoing combustion to generate thermal heat
Inductively coupled plasma operates by ionizing argon gas inside a quartz torch using radiofrequency energy. Argon is an inert, noble gas that does not undergo chemical combustion to generate heat. Instead, the plasma's high

secondary electrons from the cathode wall. This prevents continuous, uncontrolled discharge within the tube, allowing it to recover for subsequent radiation events.

165. (B) Incomplete energy deposition due to gamma rays scattering and escaping the detector
The Compton continuum observed in gamma-ray spectra is a direct consequence of partial energy deposition within the detector crystal. During Compton scattering, an incoming gamma-ray photon transfers a portion of its energy to a shell electron. The scattered photon, still carrying the remaining energy, then escapes the detector volume, resulting in a broad continuous distribution of measured energies.

166. (C) Thermal decomposition or vaporization
In thermogravimetric analysis, a mass-loss event indicates that the sample is undergoing a physical or chemical process that releases volatile components. This typically corresponds to thermal decomposition, dehydration, or vaporization as the temperature increases. Phase transitions that do not involve a change in mass, such as melting or glass transitions, cannot be detected by this technique.

167. (C) An activity of exactly 1 at a specified temperature (commonly 298.15 K)
Standard electrode potentials are thermodynamic values defined under precise standard state conditions to ensure reproducibility. For aqueous solutes, the standard state corresponds to a chemical activity of exactly one, which accounts for non-ideal ion interactions. These measurements are typically referenced to a specified temperature of 298.15 Kelvin and a standard pressure of one atmosphere.

168. (A) Nernst slope ($\frac{2.303RT}{F}$) is directly proportional to absolute temperature
Temperature compensation is essential in pH measurements because the response of the glass electrode is governed by the Nernst equation. The theoretical slope of the electrode, defined mathematically as $\frac{2.303RT}{F}$, is directly proportional to the absolute temperature. Consequently, temperature fluctuations alter the electrical potential generated per pH unit, requiring active electronic correction to maintain accuracy.

169. (A) It prevents polarization of the electrodes and changes in local concentration
Kohlrausch's method for measuring electrolyte conductivity employs alternating current rather than direct current to eliminate analytical errors. The rapidly reversing polarity of alternating current prevents electrical polarization at the electrode surfaces and minimizes faradaic reactions. This suppression of electrolysis ensures that the chemical composition and local concentration of the solution remain unchanged during the measurement.

170. (C) Ilkovic equation
The Ilkovic equation is a fundamental mathematical relationship in polarography that describes the diffusion-controlled current at a dropping mercury electrode. It quantitatively relates the maximum or average current to the number of electrons transferred, the analyte concentration, the diffusion coefficient, the rate of mercury flow, and the drop lifetime, enabling precise quantitative analysis.

171. (B) Lanthanum fluoride crystal doped with europium
Fluoride ion-selective electrodes utilize a solid-state membrane composed of a single crystal of lanthanum fluoride. To enhance electrical conductivity and facilitate ion transport through the lattice, the crystal is doped with europium, which introduces vacancy defects. This specialized membrane selectively allows fluoride ions to interact with the crystal surface, generating a measurable potential difference.

172. (B) 1.0
The relationship between light transmittance and absorbance is defined logarithmically by the Beer-Lambert law. Transmittance represents the fraction of incident light that passes through a sample, whereas absorbance is the negative logarithm of that fraction. When a solution transmits exactly ten percent of the incident light, the corresponding mathematical calculation yields an absorbance value of 1.0.

173. (B) Diffraction and interference
A grating monochromator isolates specific wavelengths of light using an optical surface ruled with thousands of closely spaced parallel grooves. When polychromatic light reflects off this surface, the wavefronts undergo diffraction. Subsequent constructive and destructive

Downloaded from www.pdf.tube

oxygen partial pressures on the reference and sample sides.

138. (C) Zero and span gas calibration routines
Continuous emission monitoring systems maintain baseline accuracy and measurement reliability through automated calibration routines. Introducing a zero gas containing none of the target analyte establishes a stable baseline, while introducing a span gas with a certified concentration calibrates the sensitivity. These regular adjustments compensate for instrument drift and environmental changes affecting detector performance.

139. (D) Primary ion pairs created without multiplication
Gas-filled detectors operating within the ionization region utilize an applied voltage that is sufficient to collect all primary ion pairs produced by incident radiation. Because the electric field strength in this region remains below the threshold for gas multiplication, no secondary ionization occurs, and the resulting current is directly proportional to the initial energy deposited.

140. (A) Visible light photons
Scintillation counters utilize thallium-activated sodium iodide crystals to detect ionizing radiation. When incident gamma rays interact with the crystal lattice, they transfer energy to electrons, raising them to excited states. As these electrons return to their ground states, the excess energy is emitted as visible light photons, which are subsequently directed toward a photodetector.

141. (A) Provide a controlled environment and remove evolved gaseous decomposition products
During thermogravimetric analysis, a continuous flow of purge gas establishes a stable and controlled chemical environment around the sample. This inert or reactive atmosphere prevents unwanted secondary reactions with ambient air. Additionally, the flowing gas continuously sweeps away evolved volatile decomposition products, preventing their condensation on the microbalance components and ensuring accurate mass measurements.

142. (B) Potassium chloride
The saturated calomel electrode is a widely used reference electrode in electrochemical measurements. It consists of elemental mercury in direct contact with a paste of sparingly soluble mercury(I) chloride. This assembly is immersed in a saturated solution of potassium chloride, which provides a constant concentration of chloride ions to maintain a stable and reproducible reference potential.

143. (C) The gradual shift in the asymmetry potential of the glass electrode over time
Industrial pH sensors require regular calibration due to gradual shifts in the asymmetry potential of the glass membrane. Over time, chemical exposure, mechanical fouling, and continuous hydration alter the electrical properties of the inner and outer glass surfaces. Periodic calibration with standard buffer solutions corrects for this drift, ensuring the accuracy of the hydrogen ion measurements.

144. (A) $HCl + CH_3COONa - NaCl$
Kohlrausch's law of independent migration of ions allows the determination of the limiting molar conductivity of weak electrolytes using strong electrolytes. For acetic acid, the sum of the limiting conductivities of hydrochloric acid and sodium acetate is calculated, and the limiting conductivity of sodium chloride is subtracted. This mathematical combination isolates the hydrogen and acetate ion contributions.

145. (B) Residual current
In polarographic analysis, residual current is the small background current measured before the applied potential reaches the reduction or oxidation threshold of the target analyte. This current consists of two main components: a non-faradaic charging current associated with the electrical double-layer at the electrode interface, and a faradaic current caused by trace electroactive impurities.

NODIA

146. (C) Measurement of absorbance near 815 nm
The quantitative analysis of trace silica in boiler water relies on the formation of silicomolybdic acid, which is chemically reduced to a dark blue complex known as heteropoly blue. This intensely colored complex exhibits a strong, characteristic absorption band in the near-infrared spectral region, permitting high-sensitivity spectrophotometric determination by measuring the light absorbance at approximately 815 nanometers.

When exposed to an external magnetic field, the magnetic moment of an unpaired electron spin splits into discrete energy levels. Irradiating the sample with microwave radiation induces transitions between these spin states, providing detailed structural and chemical environment information.

111. (D) A classic Wheatstone bridge
The Katharometer thermal conductivity analyzer utilizes heated filaments whose electrical resistance changes with temperature. To measure these small changes with high accuracy, the active sample filaments and matching reference filaments are arranged as arms within a classic Wheatstone bridge circuit. Any difference in gas thermal conductivity imbalances the bridge, generating a highly proportional electrical output signal.

112. (B) Because oxygen is uniquely attracted into a magnetic field, altering a measurable physical parameter (like flow or thermal convection).
Most common industrial gases are diamagnetic and weakly repelled by magnetic fields, whereas diatomic oxygen is strongly paramagnetic and attracted. This unique magnetic attraction is exploited in wizards to pull oxygen molecules into a concentrated magnetic field. This movement alters measurable physical parameters, such as gas flow or thermal convection, generating a highly selective and accurate signal.

113. (A) A gas filter correlation wheel or specific optical bandpass filter
Flue and combustion gases contain multiple IR-absorbing species, such as water vapor and carbon dioxide, which can overlap with the target carbon monoxide signal. NDIR analyzers utilize a gas filter correlation wheel or specialized narrow bandpass optical filters. These components isolate the exact absorption lines of carbon monoxide, effectively blocking non-target wavelengths and eliminating cross-sensitivity.

114. (B) The detector cannot record a subsequent ionizing event due to positive ion sheath accumulation.
Following an ionizing event in a Geiger-Muller tube, a sheath of slow-moving positive ions accumulates around the anode. This temporary space charge reduces the local electric field strength below the threshold required for gas multiplication. During this brief period, known as dead time, the detector is completely insensitive and cannot record any subsequent incoming radiation pulses.

115. (C) Reduce thermal generation of electron-hole pairs (leakage current)
High-purity Germanium has a relatively small band gap, meaning thermal energy at room temperature is sufficient to excite electrons into the conduction band. This thermal activity generates massive leakage currents that completely overwhelm any signals from ionizing radiation. Cooling the semiconductor crystal with liquid nitrogen minimizes these thermal excitations, drastically reducing electronic background noise.

116. (D) Step change in the baseline heat capacity
The glass transition is a second-order thermodynamic transition where an amorphous polymer transitions from a hard, glassy state to a flexible, rubbery state. This structural change does not involve latent heat, so it does not produce a peak. Instead, it alters the specific heat capacity, manifesting on a DSC curve as a distinct step-like change in the baseline.

117. (C) Whose potential responds to the activity of the analyte in solution
Unpaired electrons are highly sensitive to their local magnetic environments. Hyperfine splitting in electron spin resonance spectra arises from the magnetic coupling between the magnetic moment of the unpaired electron and the nuclear spins of adjacent magnetic nuclei, such as hydrogen or nitrogen. This coupling splits the electron resonance signal into a characteristic pattern of multiple peaks.

118. (D) Higher than the actual pH value
In extremely acidic solutions where hydrogen ion activity is exceptionally high, water molecules in the hydrated gel layer of the glass electrode can become saturated or protonated. This alters the activity of water and the ion-exchange equilibrium across the membrane. Consequently, the electrode potential deviates, causing the measured pH to appear systematically higher than the true value.

119. (A) Increase the effective surface area and minimize polarization effects
Conductivity measurements of electrolyte solutions can suffer from significant capacitive

Click Here to Buy book on Flipkart

maximizes the amount of analyte introduced, making it highly suitable for trace-level analysis where high sensitivity is required to detect low-concentration compounds.

156. (A) Trap contaminants to protect the analytical column
A guard column is a short, sacrificial cartridge installed upstream of the primary analytical column in high-performance liquid chromatography. Its primary function is to physically filter particulates and chemically retain irreversible contaminants or highly polar impurities from the sample matrix. Protecting the analytical column in this manner extends its operating lifetime and preserves chromatographic resolution.

157. (A) Absorb light at one wavelength and emit light at a longer wavelength
Fluorescence detection in liquid chromatography is a highly sensitive and selective method that relies on the photoluminescent properties of analyte molecules. When these molecules pass through the flow cell, they absorb high-energy light at a specific excitation wavelength. The excited molecules then relax, emitting light at a longer, lower-energy wavelength, which is measured by a photodetector.

158. (C) Possess no magnetic moment and thus be NMR inactive
Nuclei with a spin quantum number of zero possess an even number of both protons and neutrons, resulting in a completely symmetric nuclear charge distribution. Lacking a net nuclear spin, these isotopes do not have a magnetic moment and cannot interact with an external magnetic field. Consequently, they are completely inactive in nuclear magnetic resonance spectroscopy.

159. (C) Radio frequency (RF) and Direct Current (DC) voltages
A quadrupole mass analyzer operates as a mass filter by establishing a dynamic electrostatic field between four parallel metal rods. This field is generated by superimposing radio frequency alternating voltages onto direct current voltages. By precisely adjusting the amplitudes of these electrical signals, the analyzer selectively stabilizes the trajectories of target ions, allowing only specific mass-to-charge ratios to pass.

160. (B) 2,2-Diphenyl-1-picrylhydrazyl (DPPH)
Electron spin resonance spectrometers require precise calibration of the relationship between the applied magnetic field and the microwave frequency. The stable organic free radical 2,2-diphenyl-1-picrylhydrazyl is widely utilized as a primary reference standard for this purpose. Because its g-factor is precisely known, it provides a highly reliable calibration peak for determining free radical concentrations.

161. (B) Incomplete combustion due to insufficient oxygen or poor mixing
In industrial combustion processes, the presence of high concentrations of carbon monoxide in the flue gas indicates incomplete combustion. This condition typically arises when there is insufficient oxygen in the burner zone to completely oxidize carbon to carbon dioxide, or when poor burner mixing prevents adequate contact between fuel and air, reducing overall fuel efficiency.

162. (C) Rotate within the active magnetic field
Paramagnetic oxygen analyzers rely on the highly paramagnetic nature of oxygen molecules compared to other common flue gases. When a sample containing oxygen enters the measurement cell, the gas is drawn into the strong magnetic field, displacing a suspended glass dumbbell. This displacement causes the dumbbell to rotate, and the degree of rotation is measured using an optical detection system.

163. (C) Modulate the IR beam, creating an alternating signal that is easier to amplify and distinguish from background noise
Non-dispersive infrared analyzers utilize a rotating chopper wheel to periodically interrupt the path of the infrared light beam. This modulation converts the continuous optical signal into an alternating signal at a specific frequency. Measuring an alternating signal allows the electronics to easily distinguish the analyte absorption from constant background thermal drift, ambient light, and electronic noise.

164. (A) To absorb UV photons emitted during the avalanche and neutralize positive ions, preventing continuous discharge
In a Geiger-Muller detector, a quenching gas plays a vital role in terminating the avalanche ionization process. It absorbs ultraviolet photons generated during the discharge and neutralizes slow-moving positive ions before they can release

Downloaded from www.pdf.tube

147. (B) Remain unchanged
The Beer-Lambert law states that absorbance is directly proportional to both the optical path length and the concentration of the absorbing species. When the path length is doubled and the solute concentration is simultaneously halved, the two modifications mathematically cancel each other out. Consequently, the total absorption of light remains constant, and the measured value is unchanged.

148. (B) Focus the light onto the sample cuvette and determine the spectral bandwidth
The exit slit of a monochromator plays a critical role in controlling the spectral characteristics of the light exiting the dispersing system. By physically limiting the width of the exiting beam, it isolates a narrow band of wavelengths, thereby establishing the spectral bandwidth. This monochromatic light is then directed through the sample compartment toward the detector.

149. (A) The Jacquinot advantage (high throughput of energy)
Fourier transform infrared spectrometers provide several key performance benefits over traditional dispersive instruments, including the Jacquinot advantage. This throughput advantage arises because the system utilizes circular apertures instead of narrow slits, allowing a significantly larger portion of the source energy to reach the detector. This increased light throughput substantially improves the signal-to-noise ratio of the analysis.

150. (B) Elastic, with no change in the energy of the scattered photon
Rayleigh scattering and Raman scattering represent different physical interactions between light and matter. Rayleigh scattering is an elastic process, meaning that the incident photons collide with molecules and scatter without any net transfer of energy, leaving the scattered wavelength identical to the source. Conversely, Raman scattering is an inelastic process involving changes in vibrational or rotational energy.

151. (C) To isolate the specific emission line of the analyte from background emission and adjacent lines
In flame emission spectrometry, the high temperature of the flame excites multiple elements and generates molecular background emissions across a broad spectrum. A narrow spectral bandpass is necessary to isolate the specific emission line of the target analyte from neighboring spectral lines and background radiation. This selectivity minimizes spectral interferences and enhances the accuracy of quantitative determinations.

152. (B) Operating at low pressure and relatively low temperature to minimize Doppler and collisional broadening
Hollow cathode lamps are designed to emit extremely narrow spectral lines to ensure high selectivity in atomic absorption measurements. To prevent significant line broadening, the lamp operates under low internal gas pressure and relatively low temperatures. This specific operational design minimizes both Doppler broadening, caused by thermal motion, and collisional broadening, caused by interactions between gas particles.

153. (A) Permits simultaneous multi-element analysis over a wide linear dynamic range
Inductively coupled plasma systems offer significant analytical advantages over atomic absorption spectrophotometry, primarily due to the high temperature of the argon plasma. This excitation source enables efficient simultaneous multi-element analysis within a single sample run. Additionally, the technique provides a wide linear dynamic range, allowing the quantification of trace and major components without requiring extensive sample dilution.

154. (B) The multiple paths of different lengths that solute molecules can travel through a packed column
In chromatographic theory, eddy diffusion accounts for a significant portion of band broadening within packed columns. This phenomenon occurs because the individual molecules of a solute travel through a multitude of flow paths of varying lengths and geometries around the stationary phase particles. This unequal path distribution causes the solute zone to disperse as it migrates.

NODIA

155. (A) The entire injected sample is directed to the capillary column, useful for trace analysis
Splitless injection is a key sample introduction technique in capillary gas chromatography. During the initial injection phase, the split valve remains closed, directing the entire vaporized sample onto the analytical column. This approach

interference of these diffracted waves disperses the light into its component colors, allowing selective transmission of a narrow band.

174. (C) The thermal or pyroelectric detector (e.g., DTGS)
In Fourier transform infrared spectroscopy, the intensity of the light after passing through the sample is measured by a dedicated detector. Commonly, a pyroelectric sensor such as deuterated triglycine sulfate or a thermal transducer is employed. This detector responds rapidly to the modulated infrared radiation, converting the optical interferogram into an analog electrical signal for processing.

175. (C) Rayleigh scattering line
In Raman spectroscopy, the scattered radiation contains lines of modified frequencies alongside the dominant excitation frequency. These shifted features, known as Stokes and anti-Stokes lines, represent inelastic scattering events. They are arranged symmetrically on either side of the intense central Rayleigh line, which corresponds to the elastic scattering of light at the original incident wavelength.

176. (B) Desolvation and volatilization of the aerosol
Prior to atomization in flame emission spectrophotometry, the liquid sample must undergo several physical transformations within the burner assembly. After the nebulizer creates a fine aerosol, the flame heat evaporates the solvent in a process called desolvation. The remaining solid particles are then vaporized into gaseous molecules, which finally dissociate into free ground-state atoms.

177. (B) An emission line of an interfering element overlaps the analyte absorption line
Spectral interference in atomic absorption spectrophotometry occurs when physical or optical signals overlap with the specific wavelength of the analyte. This typically happens when an emission or absorption line of an accompanying matrix element is so close to the analyte line that the monochromator cannot resolve them, resulting in artificially elevated absorbance readings.

178. (C) Collisional excitation within a high-temperature argon plasma
In inductively coupled plasma atomic emission spectrophotometry, excitation is achieved through high-energy interactions within an argon plasma torch. At temperatures reaching up to ten thousand Kelvin, the gaseous sample undergoes rapid desolvation, atomization, and ionization. Collisions with energetic argon atoms and free electrons excite the analyte, which then emits characteristic light upon relaxation.

179. (C) Have a stronger affinity for the stationary phase and elute later
The partition coefficient represents the ratio of solute concentration in the stationary phase compared to the mobile phase at equilibrium. A solute with a larger partition coefficient has a stronger thermodynamic affinity for the stationary phase. Consequently, it spends a greater fraction of time immobilized, resulting in slower migration through the column and a later elution time.

180. (B) Concentration-sensitive, non-destructive detector
The thermal conductivity detector in gas chromatography is classified as a concentration-sensitive, non-destructive detector. It measures the change in thermal conductivity of the carrier gas stream as analytes emerge from the column. Because the sensing process does not chemically alter or destroy the analyte molecules, they can be collected downstream for further characterization if desired.

181. (A) Highly polar, such as bare silica
Normal-phase high-performance liquid chromatography is defined by its specific combination of phase polarities. The stationary phase utilized in this technique is highly polar, with unmodified bare silica being the most common choice. In contrast, the mobile phase consists of non-polar or moderately polar organic solvents, causing polar analytes to be retained more strongly on the column.

182. (D) The absence of chromophores in the sample
A refractive index detector operates by measuring changes in the bulk deflection of light passing through the mobile phase. This detector is highly sensitive to variations in temperature and solvent composition, which directly affect baseline stability. However, because it is a universal detector, the presence or absence of light-absorbing chromophores in the sample does not affect its performance.

Click Here to Buy book on Amazon

temperatures are generated solely through resistive heating caused by the movement of ions and electrons in the oscillating magnetic field.

129. (A) $H = \frac{L}{N}$

The height equivalent to a theoretical plate is a key parameter that quantifies the efficiency of a chromatographic column. It is mathematically calculated by dividing the physical length of the column by the total number of theoretical plates. A smaller plate height indicates narrower peaks and higher separation efficiency, reflecting minimized band broadening during migration.

130. (D) Ion currents produced in a hydrogen-air flame

The flame ionization detector operates by burning eluting organic compounds in a high-temperature hydrogen-air flame. This thermal process Pyrolyzes hydrocarbons to produce ions, primarily CHO+ species. Applying a potential difference across the flame collects these generated ions, creating an electric current that is directly proportional to the concentration of carbon atoms in the sample.

131. (A) Decrease

Reversed-phase liquid chromatography utilizes a non-polar stationary phase, meaning hydrophobic analytes are strongly retained through hydrophobic interactions. The elution strength of the mobile phase is increased by decreasing its polarity. Adding a less polar organic solvent, such as methanol, enhances the solubility of hydrophobic analytes in the mobile phase, thereby decreasing their retention times on the column.

132. (A) Acquire full-range UV-Vis absorption spectra continuously in real-time

Traditional variable wavelength detectors can only monitor a single selected wavelength at a time. In contrast, a diode array detector utilizes a polychromator paired with a photodiode array to capture transmitted light across the entire ultraviolet and visible spectrum simultaneously. This allows continuous, real-time acquisition of full absorption spectra for every eluting peak during the run.

133. (B) External magnetic field strength

Continuous wave nuclear magnetic resonance spectroscopy relies on systematically sweeping through resonance conditions to record a spectrum. This is typically achieved by keeping the excitation radiofrequency completely constant while slowly changing the external magnetic field strength. As the local field at each chemically shielded nucleus satisfies the Larmor resonance condition, energy absorption is detected and recorded.

134. (B) Atmospheric Electrospray Ionization (ESI)

Electrospray ionization is a highly gentle, soft ionization technique that operates at atmospheric pressure. It transfers solution-phase ions directly into the gas phase by applying a high voltage, producing protonated molecular ions with minimal excess internal energy. Consequently, the resulting mass spectrum is dominated by intact molecular species, with virtually no fragment peaks observed.

NODIA

135. (C) Neighboring magnetic nuclei (such as protons)

Unpaired electrons are highly sensitive to their local magnetic environments. Hyperfine splitting in electron spin resonance spectra arises from the magnetic coupling between the magnetic moment of the unpaired electron and the nuclear spins of adjacent magnetic nuclei, such as hydrogen or nitrogen. This coupling splits the electron resonance signal into a characteristic pattern of multiple peaks.

136. (A) Increase in resistance due to the heat of catalytic oxidation of the combustibles

Catalytic bead sensors detect combustible gases through controlled oxidation on a specialized catalyst-coated element. When unburned combustibles contact the heated bead, catalytic combustion occurs, releasing thermal energy that raises the temperature of the internal platinum wire. This temperature increase directly causes a proportional change in electrical resistance, which is measured using a balanced Wheatstone bridge.

137. (A) The partial pressures of oxygen across the solid electrolyte

At elevated temperatures, zirconium oxide acts as a solid electrolyte that selectively conducts oxygen ions. When different concentrations of oxygen exist on opposite sides of the ceramic membrane, a potential difference is established across the cell. This generated voltage is logarithmically proportional to the ratio of the

mathematical model relates the measured cell potential to the standard electrode potential, the operating temperature, and the chemical activities of the oxidized and reduced species in solution, establishing a quantitative link between voltage and ion concentration.

193. (A) Silver/Silver Chloride (Ag/AgCl) junction
The glass pH electrode contains an internal reference system that provides a stable reference potential for the pH-sensitive glass membrane. This internal element is typically constructed as a silver wire coated with a layer of silver chloride, immersed in a buffered chloride solution of constant concentration. This silver-silver chloride junction maintains highly reproducible electrochemical performance.

194. (C) Standard potassium chloride (KCl)
To calibrate the cell constant of a conductivity probe, standard solutions of high stability and precisely known specific conductivity are required. Potassium chloride is the universally accepted reference solute for this application. Standard aqueous solutions of potassium chloride are prepared at precise concentrations, providing highly reproducible conductivity values across a wide range of laboratory and industrial temperatures.

195. (C) The electrode surface is continuously renewed, preventing surface fouling
In classical polarography, the dropping mercury electrode provides exceptional reproducibility because of its dynamic nature. As mercury slowly flows through a fine capillary, it continuously forms fresh, identical droplets that eventually detach. This continuous renewal of the active electrode surface prevents chemical fouling, adsorption of reaction products, and accumulation of impurities, maintaining a clean interface.

196. (A) Logarithm of the ion's activity
Specific ion meters utilize ion-selective electrodes to measure target analytes based on potentiometric principles. The electric potential developed across the selective membrane is mathematically described by the Nernst equation. This relationship states that the generated voltage is directly proportional to the logarithm of the target ion's chemical activity, rather than its absolute physical concentration.

197. (D) 100%
According to the Beer-Lambert law, absorbance and transmittance represent inverse logarithmic measures of light attenuation. When a solution has an absorbance value of zero, it means that absolutely no electromagnetic radiation is absorbed or scattered by the sample. Under these conditions, all incident light passes through completely, resulting in a measured transmittance of one hundred percent.

198. (C) An optical beam splitter
A double-beam UV-Vis spectrophotometer operates by continuously comparing the light intensity passing through the sample and reference cells. This configuration requires an optical beam splitter, such as a rotating chopper mirror or a stationary half-silvered mirror, to divide the light beam. This critical optical component is completely absent from simpler single-beam instrument designs.

199. (B) Silicon carbide heated electrically
The Globar is a robust and widely used source of mid-infrared radiation in spectroscopy. It is constructed from a rod of silicon carbide that is electrically heated to elevated temperatures, typically between eleven hundred and fifteen hundred degrees Celsius. At these high temperatures, the silicon carbide rod acts as a stable blackbody emitter, producing continuous infrared light.

200. (B) An intense monochromatic light source, typically a laser
Raman scattering is an extremely weak optical phenomenon, with only a tiny fraction of incident photons undergoing inelastic scattering. To generate a detectable signal, modern instruments require an exceptionally intense, monochromatic light source. Laser systems provide the necessary high power density and narrow spectral line width to excite the sample and resolve the weak Raman-shifted signals.

201. (C) Alkali metals (e.g., Sodium, Potassium)
Flame emission spectrophotometry is a highly sensitive and specialized method primarily used for the routine quantitative analysis of alkali and alkaline earth metals. Elements such as sodium, potassium, and lithium have relatively low excitation energies. The heat of a standard burner flame is sufficient to excite these atoms,

Downloaded from www.pdf.tube

which then emit characteristic visible light upon relaxation.

202. (A) Measuring total absorbance and background absorbance alternately and subtracting the background
Background correction using a deuterium continuum source in atomic absorption spectrophotometry operates through a dual-beam measurement. The instrument rapidly alternates between a hollow cathode lamp, which measures total absorbance, and a deuterium lamp, which measures only non-specific background absorption. Subtracting the background absorbance from the total absorbance isolates the true atomic absorption signal of the analyte.

203. (B) Charge-Coupled Device (CCD) or similar array detector
In modern inductively coupled plasma atomic emission systems, capturing simultaneous emission spectra across multiple wavelengths is essential for high-throughput analysis. This is achieved using solid-state array detectors, such as charge-coupled devices. These multi-element sensors can monitor thousands of individual spectral lines simultaneously, enabling rapid, comprehensive elemental analysis of complex samples in a single run.

204. (D) Narrow, sharp peaks indicating high efficiency
The theoretical plate count is a fundamental metric used to evaluate the efficiency of a chromatographic column. A high number of theoretical plates indicates that the column minimizes band broadening as the solute bands migrate. Consequently, this high efficiency results in very narrow, sharp chromatographic peaks, which significantly improves the resolution of closely eluting components.

205. (A) Helium or Nitrogen
The flame ionization detector requires an inert carrier gas to transport analytes through the column without contributing to the background flame ionization signal. Helium and nitrogen are the most commonly utilized carrier gases, offering an optimal balance of chromatographic efficiency, safety, and compatibility. Separate streams of hydrogen and air are supplied to sustain the detector flame.

206. (C) Increased column efficiency accompanied by higher backpressure
Decreasing the particle size of the stationary phase packing material in high-performance liquid chromatography has significant physical consequences. It reduces the diffusion distances within the mobile and stationary phases, thereby increasing column efficiency and chromatographic resolution. However, smaller particles also restrict fluid flow, which exponentially increases the operating backpressure required to maintain the flow rate.

207. (A) Refractive Index (RI) Detector
The refractive index detector is classified as a bulk property detector because it measures changes in the overall physical properties of the eluent. Because refractive index is highly sensitive to slight variations in temperature and solvent composition, maintaining a stable baseline is extremely difficult during gradient elution, where the mobile phase composition changes continuously.

NODIA

208. (A) Time domain to the frequency domain
In modern nuclear magnetic resonance spectroscopy, the raw signal collected after a radiofrequency pulse is the free induction decay, which represents nuclear precession as a function of time. To convert this complex, overlapping time-domain signal into a readable frequency-domain spectrum of individual peaks, the mathematical process of Fourier transformation is applied.

209. (C) Time-of-Flight (TOF)
The time-of-flight mass analyzer operates on the principle that ions accelerated by an electric field receive equivalent kinetic energy. When these ions enter a field-free drift tube, their velocities depend strictly on their mass-to-charge ratios. Lighter ions travel faster than heavier ones, allowing the mass analyzer to separate them by measuring their arrival times.

210. (C) Energy gap between split electron spin states
In electron spin resonance spectroscopy, placing a sample containing unpaired electrons into a strong external magnetic field splits the degenerate electron spin states. As the magnetic field is varied, resonance occurs when the energy of the applied microwave radiation precisely matches the energy gap between these split spin states, inducing transition between the levels.

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

211. (C) Thermal conductivity of the gas mixture
A Katharometer is a specialized thermal conductivity detector used in industrial gas analysis. It operates by measuring changes in the rate of heat loss from a heated electrical filament to the surrounding gas stream. Because different gases possess distinct thermal conductivities, variations in the composition of the flue gas directly alter the filament temperature and resistance.

212. (C) Diamagnetic
Oxygen is highly unique among common atmospheric gases due to its paramagnetic properties, which arise from its two unpaired electrons. In contrast, other major components of flue gas and ambient air, such as nitrogen, carbon dioxide, and water vapor, possess fully paired electron configurations, making them diamagnetic and weakly repelled by magnetic fields.

213. (B) Ozone
Industrial chemiluminescence analyzers quantify nitrogen oxides by exploiting the gas-phase chemical reaction between nitric oxide and ozone. This reaction produces electronically excited nitrogen dioxide molecules. As these excited molecules return to their ground state, they emit light in the red to infrared region, the intensity of which is directly proportional to the nitric oxide concentration.

214. (B) Ionization chamber region
The ionization chamber region of a gas-filled detector's voltage curve is characterized by complete collection of all primary ion pairs. In this operating range, the applied voltage is high enough to prevent the recombination of positive ions and free electrons, yet low enough to avoid secondary gas multiplication, resulting in a current independent of voltage.

215. (A) A solid-state diode
Semiconductor radiation detectors function in a manner analogous to a solid-state diode operated under a high reverse bias. The applied reverse voltage creates a wide depletion region within the high-purity semiconductor crystal, which acts as the sensitive volume. When ionizing radiation enters this region, it generates electron-hole pairs that are collected to produce a signal.

216. (A) It depends on the specific instrument convention (can be up or down, but is opposite to endothermic peaks)
In differential scanning calorimetry, the direction of exothermic peaks relative to the baseline depends on the specific instrument convention used, which can designate exothermic heat flow as either upwards or downwards. Regardless of the chosen convention, an exothermic process, such as crystallization, will always produce a peak that points in the opposite direction of an endothermic process.

217. (A) An electrode of the second kind
An electrode of the second kind is an electrochemical reference electrode where a metal is in contact with a layer of its own sparingly soluble salt, bathed in a solution containing the anion of that salt. The potential of this half-cell is stable because it is determined by the constant activity of the anion in solution.

218. (B) The chemical activity of hydrogen ions
Glass pH electrodes do not respond directly to the molar concentration of hydrogen ions, but rather to their chemical activity at the glass-solution interface. In solutions of high ionic strength, electrostatic interactions modify the activity coefficient of the ions. Consequently, temperature and thermodynamic activity, rather than physical concentration, dictate the potentiometric response of the pH meter.

219. (B) cm^{-1}
The cell constant of a conductivity probe is defined geometrically as the ratio of the distance between the two electrode plates to their cross-sectional area. Mathematically, this calculation yields a unit of reciprocal length. Consequently, in scientific and industrial measurements, the cell constant is typically expressed in units of reciprocal centimeters or reciprocal meters.

220. (C) The migration current
In polarographic analysis, a supporting electrolyte is added in large excess to carry the bulk of the electrical current through the solution. This excess of inert ions screens the electric field, thereby suppressing the electrostatic migration of charged analyte ions toward the electrode. This ensures that analyte transport is governed solely by diffusion, enabling quantitative measurement.

Click Here to Buy book on Flipkart

primary ionization event. Unlike a Geiger-Muller tube, where the avalanche spreads along the entire anode, this localized ionization prevents saturation. Consequently, the amplitude of the resulting electrical pulse remains directly proportional to the energy deposited by the incident radiation.

240. (D) Photopeak corresponding to the full energy of the gamma ray, along with a Compton continuum
Gamma spectrometry using a thallium-activated sodium iodide detector produces a characteristic energy spectrum. This spectrum features a well-defined photopeak, which corresponds to the complete energy deposition of the gamma ray via the photoelectric effect. It also displays a broad Compton continuum, representing events where scattered photons escaped the active volume of the scintillator.

241. (D) Melting without mass change
Thermogravimetric analysis is limited to monitoring physical and chemical processes that result in a change in sample mass. Events such as decomposition, dehydration, and oxidation are easily detected. However, melting represents a solid-to-liquid phase transition that occurs without any net mass change, making it invisible to the sensitive microbalance used in this technique.

242. (C) The internal electrolyte concentration is kept constant
Standard reference electrodes maintain a highly stable and reproducible potential because their chemical design keeps the internal electrolyte concentration constant. In a saturated calomel electrode, the surrounding solution remains saturated with potassium chloride, ensuring a constant activity of chloride ions. This stable chemical environment prevents shifts in the half-cell potential during electrochemical measurements.

243. (B) Identical solutions face both sides of the glass membrane
The asymmetry potential of a glass pH electrode is a small electrical potential that exists across the glass membrane under symmetric conditions. This potential is observed even when identical solutions face both the inner and outer surfaces of the glass. It is caused by minor structural differences, manufacturing strains, or uneven hydration of the glass surfaces.

NODIA

244. (C) Faradaic polarization of the electrodes may occur, altering the measured resistance
In conductivity measurements, applying an alternating current of sufficient frequency is critical. If the frequency is too low, the electrical conditions resemble direct current, causing faradaic polarization of the electrodes. This leads to the buildup of ion layers at the interfaces, introducing a polarization resistance that artificially alters the measured resistance of the bulk solution.

245. (C) Is characteristic of the specific electroactive species, providing qualitative information
In polarographic analysis, the half-wave potential serves as a key qualitative diagnostic parameter. This specific potential is defined as the point on the polarographic wave where the current reaches half of its limiting diffusion value. Because the half-wave potential is independent of analyte concentration, it is characteristic of the specific electroactive species being analyzed.

246. (C) Nicolsky-Eisenman equation
The selectivity of an ion-selective electrode in the presence of interfering ions is mathematically described by the Nicolsky-Eisenman equation. This equation is an extension of the Nernst equation that incorporates a selectivity coefficient to quantify the electrode's response to primary and interfering ions. It enables analysts to predict measurement errors in complex sample matrices.

247. (A) Monochromatic
The Beer-Lambert law is derived under several fundamental physical assumptions to ensure a linear relationship between absorbance and concentration. One primary assumption is that the incident radiation is strictly monochromatic. Utilizing polychromatic light introduces non-linearities because different wavelengths exhibit different molar absorptivities, resulting in systematic deviations from the law during spectrophotometric analysis.

248. (B) Utilizing a beam splitter to pass light simultaneously through both sample and reference cells to two matched detectors
A double-beam in-space spectrophotometer achieves real-time background correction by

sensitive device. It operates by measuring a decrease in standing current when electronegative analytes capture thermal electrons generated by a radioactive beta source. This mechanism makes the detector exceptionally sensitive to halogenated organic compounds, nitriles, and highly conjugated systems.

231. (B) Dramatically decreases the total analysis time for samples with widely varying polarities
Gradient elution in high-performance liquid chromatography involves continuously changing the mobile phase composition during the analytical run. This technique is highly superior to isocratic elution when separating mixtures containing components with widely varying polarities. It accelerates the elution of strongly retained analytes, preventing peak broadening, improving resolution, and significantly reducing the total analysis time.

232. (C) Lack a UV chromophore but are less volatile than the mobile phase
The evaporative light scattering detector is a valuable alternative in liquid chromatography for compounds that lack ultraviolet chromophores. The detector operates by nebulizing the column effluent, vaporizing the volatile mobile phase, and measuring light scattered by the remaining solid analyte particles. Consequently, the analyte must be significantly less volatile than the mobile phase to be detected.

233. (A) Local electronic environment (shielding/ deshielding effects)
In nuclear magnetic resonance spectroscopy, the chemical shift of a nucleus is dictated by its local electronic environment. Surrounding electrons create local magnetic fields that shield the nucleus from the applied external magnetic field. Electronegative atoms or nearby unsaturated bonds alter this electron density, deshielding the nucleus and shifting its resonance frequency.

234. (C) Droplets undergo coulombic fission to form gas-phase ions
In electrospray ionization mass spectrometry, a high voltage applied to the capillary generates highly charged droplets. As the solvent continuously evaporates from these droplets, their size decreases, concentrating the surface charge. Once the electrostatic repulsion exceeds the surface tension, the droplets undergo coulombic fission, repeatedly breaking into smaller droplets until free gas-phase ions are released.

235. (A) Electron Paramagnetic Resonance (EPR)
Electron spin resonance is a spectroscopic technique used to study chemical species containing unpaired electrons. In scientific literature and instrumentation, this method is practically synonymous with electron paramagnetic resonance. Both terms describe the same physical process of absorbing microwave radiation to induce transitions between electron spin energy states in a controlled magnetic field.

236. (C) Platinum or Tungsten
A Katharometer utilizes heated filaments arranged in a balanced Wheatstone bridge configuration to monitor changes in thermal conductivity. The filaments must be constructed from materials with a high temperature coefficient of electrical resistance, such as platinum or tungsten. This material property ensures that small changes in temperature produce significant, easily measurable shifts in electrical resistance.

237. (B) Galvanic concentration cell
A zirconium oxide oxygen sensor operates as a solid-state galvanic concentration cell. At elevated temperatures, the zirconium ceramic acts as a solid electrolyte, allowing oxygen ions to migrate through its structure. The difference in oxygen concentration between the sample and reference gases generates a potential difference across the cell, serving as a direct measure of oxygen.

238. (C) An optical bandpass filter specific to the target gas's absorption wavelength
In non-dispersive infrared analyzers, the complex dispersing elements found in standard spectrophotometers, such as gratings or prisms, are omitted. Instead, the instrument utilizes an optical bandpass filter designed to transmit only the specific wavelength region absorbed by the target gas. This simplifies the optical path while maintaining high selectivity for the monitored pollutant.

NODIA

239. (B) Localized near the primary ionization event, allowing pulse height to remain proportional to primary energy
In a proportional counter, the gas multiplication process remains localized near the site of the

221. (C) A reducing agent such as amino-naphthol-sulfonic acid (ANSA) or ascorbic acid
The determination of silica using the heteropoly blue method requires a chemical reduction step to produce the intensely colored, blue-absorbing complex. After the initial reaction forms molybdosilicic acid, a selective reducing agent such as amino-naphthol-sulfonic acid or ascorbic acid is added. This reagent reduces the heteropoly acid complex without affecting excess unreacted molybdate ions.

222. (B) Absorbing species share identical molar absorptivity
An isosbestic point is a specific wavelength in absorption spectroscopy where the total absorbance of a sample remains constant during a chemical reaction or physical transition. This phenomenon occurs because the different interconverting species in the system share identical molar absorptivity values at this wavelength, meaning their individual concentration changes do not alter the overall light absorption.

223. (A) Fused silica or quartz
In ultraviolet spectrophotometry, selecting the correct cuvette material is critical because standard borosilicate glass and typical optical plastics absorb light below 350 nanometers. For accurate measurements in the ultraviolet range, cuvettes constructed from fused silica or high-purity quartz are required because these materials exhibit excellent, near-perfect optical transparency down to approximately 190 nanometers.

224. (B) The optical path difference created by the moving mirror
In Fourier transform infrared spectroscopy, the raw analytical signal is known as an interferogram. This complex waveform represents the intensity of the infrared radiation reaching the detector plotted as a function of the optical path difference. This difference is continuously generated by the precise physical movement of the moving mirror inside the Michelson interferometer.

225. (A) Rotational or vibrational energy state transitions of the molecule
The fundamental basis of Raman spectroscopy is the inelastic scattering of light by molecules. The shift in energy between the incoming excitation photon and the scattered photon corresponds to the energy required to excite molecular vibrations or rotations. Consequently, measuring these energy differences provides a unique spectral fingerprint representing the chemical bonds within the sample.

226. (B) Direct concentration of the analyte in the sample
In flame emission spectrophotometry, the sample is aspirated into a burner where the heat thermalizes and excites the constituent atoms. The intensity of the characteristic light emitted as these excited atoms return to the ground state is directly proportional to the concentration of the analyte in the sample, facilitating straightforward calibration and quantitative analysis.

227. (A) Releasing agent
In atomic absorption spectrophotometry, chemical interferences occur when matrix anions, such as phosphate, react with analyte cations, like calcium, to form thermally stable compounds. Adding lanthanum mitigates this issue because lanthanum acts as a releasing agent. It binds preferentially to the phosphate ions, releasing the calcium atoms to be freely atomized in the flame.

228. (B) Passing a high flow rate of tangential cooling argon gas along the inner walls of the torch
The argon plasma inside an inductively coupled plasma torch operates at extremely high temperatures, which would easily melt the quartz structure. To prevent thermal damage, a high flow rate of argon gas is introduced tangentially along the inner walls of the torch. This outer gas flow acts as a thermal barrier, isolating and cooling the quartz walls.

229. (B) Dead time (or void time)
In a chromatographic run, the dead time, also referred to as the void time, represents the time required for a non-retained component to travel through the column. This parameter indicates the rate at which the mobile phase itself passes from the injector to the detector, serving as a critical baseline value for calculating retention factors.

230. (B) Electronegative functional groups, such as halogens
The electron capture detector used in gas chromatography is a highly selective and

Downloaded from www.pdf.tube

splitting the light path. It utilizes a static optical beam splitter to divide the monochromatic light, passing it simultaneously through both the sample and reference cells. The light from these two paths is then captured by two separate, matched photodetectors to record absorbance.

249. (B) Track mirror position and calibrate wavelengths
In Fourier transform infrared spectrometers, a helium-neon laser is integrated into the interferometer system as an internal reference. Because the laser emits light at a highly stable, precise wavelength, its interference pattern is used to track the exact physical position of the moving mirror. This precise measurement enables accurate wavelength calibration of the infrared spectra.

250. (D) 1 in 1,000,000 to 10,000,000
Raman scattering is an inherently inefficient process because the vast majority of incident photons undergo elastic Rayleigh scattering. Statistically, only a minute fraction of the incoming radiation, typically one in one million to ten million photons, undergoes inelastic scattering. This extremely low conversion efficiency necessitates the use of high-power excitation lasers and sensitive optical detectors.

251. (A) Convert the liquid sample into a fine aerosol mist for introduction into the flame
The nebulizer is a critical sample introduction component in flame emission spectrophotometry. Its primary function is to draw up the liquid sample and mix it with high-velocity burner gases. This physical shearing action breaks the liquid stream into a fine aerosol mist of uniform droplets, ensuring efficient transport into the high-temperature flame for subsequent atomization.

252. (C) The specific element that comprises the cathode material
Hollow cathode lamps are designed to emit the precise atomic emission spectrum required for atomic absorption spectrophotometry. The cathode cup inside the lamp is constructed from, or lined with, the specific element of interest. Sputtering of these metal atoms within the glow discharge produces narrow, characteristic spectral lines that match the absorption profile of the analyte.

253. (C) Radio-frequency induction coil surrounding the torch
In an inductively coupled plasma torch, the high-temperature argon plasma is initiated and sustained by an intense, oscillating electromagnetic field. This field is generated by a radio-frequency induction coil that closely surrounds the outer quartz tube of the torch. The alternating magnetic field induces circular currents in the ionization gas, maintaining the plasma via resistive heating.

NODIA

254. (C) The Resistance to mass transfer term (C)
The van Deemter equation models column band broadening using three primary kinetic terms. The resistance to mass transfer term, represented by the coefficient C, describes the finite rate of solute equilibration between the mobile and stationary phases. This specific term is directly proportional to the linear velocity of the mobile phase, increasing column dispersion at higher flow rates.

255. (C) Improve the separation of components with a wide range of boiling points, reducing total run time
Temperature programming in gas chromatography is a powerful technique used to optimize the separation of complex mixtures. By systematically increasing the column temperature during a run, highly volatile compounds are resolved at lower temperatures, while strongly retained, high-boiling compounds are rapidly eluted at higher temperatures. This approach improves peak resolution and drastically reduces the total analysis time.

256. (B) A single continuous piece of porous material rather than individual packed particles
A monolithic high-performance liquid chromatography column represents a major departure from traditional packed columns. Instead of containing individual micro-particles, a monolith consists of a single, continuous rod of highly porous silica or organic polymer. This unique continuous structure features interconnected macropores and mesopores, which permit high flow rates and rapid mass transfer at reduced operating backpressures.

257. (A) Its continuous requirement for a matched reference flow makes baseline stabilization impossible as solvent composition changes
The refractive index detector is highly incompatible with gradient elution in liquid chromatography. Because it measures the difference in refractive index between the sample stream and a reference cell, any change in mobile phase composition causes a massive shift in baseline. Maintaining a matched reference flow is impossible as the solvent ratio continuously alters during gradient programs.

258. (C) Applied external magnetic field (B_0) increases
The Larmor frequency of a nucleus in a magnetic field describes its rate of precession. This frequency is directly proportional to the strength of the applied external magnetic field, as defined by the fundamental resonance equation. Consequently, increasing the strength of the spectrometer's magnet increases the Larmor frequency, leading to higher resolution and sensitivity.

259. (A) Has a theoretically unlimited upper mass range
The time-of-flight mass analyzer is uniquely suited for analyzing large biological macromolecules because it possesses a theoretically unlimited upper mass range. Because the analyzer separates ions based solely on their velocity down a field-free drift tube rather than using physical mass filters, even extremely heavy, singly charged proteins can be successfully transmitted and detected.

260. (A) Stable organic free radical
DPPH is chemically classified as a stable organic free radical. Its remarkable stability arises from the steric hindrance of the phenyl rings and the delocalization of the unpaired electron across the nitrogen-centered radical structure. This stability makes it an exceptional, long-lived standard for calibrating the magnetic field and g-factor in electron spin resonance spectrometers.

261. (C) Fuel-rich combustion conditions or poor burner mixing
In industrial combustion plants, the presence of unburned combustibles in flue gases indicates incomplete combustion. This condition is a primary symptom of fuel-rich operating conditions where oxygen is insufficient to oxidize the fuel completely. Alternatively, it can be caused by poor mechanical mixing within the burner, which prevents adequate oxygen contact with the fuel.

262. (B) Heated Zirconium oxide sensor
For high-temperature, in-situ oxygen measurements directly within a combustion stack, the heated zirconium oxide sensor is the most suitable technology. This solid-state sensor is highly rugged and operates optimally at temperatures above six hundred degrees Celsius. This eliminates the need for complex, heated sample-conditioning lines, providing reliable, real-time measurements in harsh, corrosive environments.

263. (C) It passes broadband infrared light through the sample without separating it into a continuous spectrum using a prism or grating
Non-dispersive infrared technology is designated as non-dispersive because the instrument does not utilize any physical dispersion elements, such as prisms or diffraction gratings, to separate the light. Instead, a broadband source of infrared radiation is directed straight through the sample chamber, and selective optical filters isolate the specific wavelengths absorbed by the analyte.

264. (B) A positive gas ion and a free electron
The fundamental detection mechanism in gas-filled radiation detectors relies on primary ionization. When incident ionizing radiation collides with neutral gas atoms or molecules within the detector chamber, it transfers sufficient energy to strip away valence electrons. This interaction generates an ion pair, which consists of a positive gas ion and a highly mobile free electron.

265. (A) Trapping centers for charge carriers, degrading the energy resolution
High-purity materials are essential for semiconductor detectors because any impurities within the crystal lattice create intermediate energy levels in the bandgap. These states act as trapping centers that capture radiation-induced charge carriers. This trapping reduces the efficiency of charge collection and fluctuates the signal amplitude, which severely degrades the overall energy resolution of the detector.

Click Here to Buy book on Amazon

266. (A) Thermal stability and compositional fraction of volatile components
A standard thermogravimetric analysis curve plots the change in sample mass as a function of temperature under a controlled atmosphere. This measurement provides primary information regarding the thermal stability of the material, indicating the onset of decomposition. Additionally, it quantifies the precise compositional fraction of volatile components, moisture, bound hydrates, and inorganic ash residues.

267. (D) Half-cell against which the indicator is measured
In any potentiometric electrochemical cell, the reference electrode serves a critical, passive role as the standard comparison point. It is designed as a stable half-cell with a constant, reproducible potential that remains unaffected by the sample composition. The active potential of the indicator electrode is measured directly against this reference potential to determine analyte activity.

268. (C) 59.16 mV
The conversion of an electrical potential into a pH reading is governed by the Nernst equation. At the standard calibration temperature of twenty-five degrees Celsius, the theoretical slope of a glass electrode is equal to 59.16 millivolts. Therefore, a change of exactly one pH unit corresponds to a measured potential difference of approximately 59.16 millivolts.

269. (A) Interionic attractions (retardation forces) decrease as ions move further apart
The equivalent conductance of a strong electrolyte increases upon dilution because strong electrolytes are completely dissociated in solution. At high concentrations, electrostatic interionic attractions create retardation forces that restrict ion mobility. Dilution increases the average distance between these ions, minimizing these interionic attractions and allowing the charge carriers to move more freely under an applied field.

270. (C) The unequal distribution and exchange of fluoride ions across the phase boundary between the crystal and the solution
The electrical potential generated across a fluoride-selective crystalline membrane is established at the interface between the solid phase and the aqueous solution. This potential is a result of the unequal distribution and selective thermodynamic exchange of fluoride ions across the phase boundary. This charge separation creates a potential difference that is logarithmically proportional to fluoride activity.

****

NODIA

CHAPTER 07
Real Time and Embedded Systems

2019

1. Which of the following best defines a real-time embedded system?
(A) A system that prioritizes user interface responsiveness over strict timing constraints
(B) A general-purpose system capable of running multiple operating systems simultaneously
(C) A data processing unit that executes tasks sequentially without external interrupts
(D) A computing system designed for specific control functions with strict deterministic timing constraints

2001

2. What distinguishes a hard real-time system from a soft real-time system?
(A) Hard real-time systems allow occasional missed deadlines without catastrophic failure
(B) Soft real-time systems require custom hardware components for execution
(C) Missing a deadline in a hard real-time system leads to total system failure
(D) Soft real-time systems strictly operate without an operating system

2023

3. Which of the following is a fundamental constraint in the design of portable embedded systems?
(A) Unlimited memory availability
(B) Stringent power consumption limits
(C) Continuous access to high-bandwidth networks
(D) Requirement for active cooling mechanisms

2018

4. Identify the INCORRECT statement regarding the characteristics of embedded systems.
(A) They are typically designed to perform a single or a few dedicated functions
(B) They often operate in reactive environments responding to external stimuli
(C) They frequently have strict constraints regarding size and weight
(D) They are exclusively implemented using full-custom VLSI circuits

2014

5. In the context of real-time systems, what does the term "determinism" refer to?
(A) The ability to guarantee a specific response within a predictable timeframe
(B) The capacity to allocate physical memory dynamically during program execution
(C) The process of resolving compilation and linking errors prior to execution
(D) The statistical probability of a system operating without hardware failures

2010

6. Which metric is most critical when designing an embedded system for a battery-operated medical implant?
(A) Maximum display resolution
(B) Throughput of floating-point operations
(C) Energy efficiency and leakage power
(D) Support for high-level scripting languages

2014

7. What is a primary engineering challenge in Hardware/Software optimization?
(A) Balancing the trade-off between execution speed and power consumption
(B) Minimizing overall silicon area while maintaining software flexibility
(C) Porting legacy software to new architectures without any performance profiling
(D) Eliminating physical memory bottlenecks by using only assembly language

2016

8. Time-to-market is a critical design metric. How does it generally affect embedded system design?
(A) It encourages custom ASIC fabrication over programmable logic solutions
(B) It necessitates custom transistor-level layout design for all circuits
(C) It requires bypassing logic simulation in favor of early prototype building
(D) It promotes using pre-designed IP cores and standard COTS components

2016

9. Non-Recurring Engineering (NRE) cost refers to which of the following?

Downloaded from www.pdf.tube

(A) The continuous cost of manufacturing each individual unit
(B) The one-time cost of researching, designing, and testing a new product
(C) The cost associated with software updates post-release
(D) The electricity cost for running the embedded system over its lifetime

2002

10. Consider the assertion and reason statements regarding general-purpose processors and Application-Specific Integrated Circuits (ASICs).
Assertion (A): General-purpose processors have lower NRE costs compared to full-custom ASICs for low-volume production.
Reason (R): General-purpose processors are mass-produced by vendors and merely programmed by the system designer, distributing the chip design cost across many users.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2004

11. Which processor technology typically offers the highest performance for a specific algorithmic task?
(A) General-purpose microprocessor
(B) Microcontroller with a basic ALU
(C) Software interpreter running on a general-purpose OS
(D) Single-purpose custom processor

2006

12. What is a key characteristic of an Application-Specific Instruction-Set Processor (ASIP)?
(A) Its instruction set is tailored to a specific application domain
(B) It uses fixed hardwired logic without any programmable execution path
(C) It cannot be programmed using standard high-level programming languages
(D) It is fundamentally designed for general-purpose high-performance server tasks

2010

13. Which of the following is an advantage of using a general-purpose processor in embedded design?
(A) It provides highly optimized power consumption for each specific task
(B) It allows rapid development with widely available software tools
(C) It significantly limits software flexibility and design programmability
(D) It requires highly specialized and expensive custom chip fabrication

2017

14. Which design metric often suffers the most when replacing a single-purpose processor with a general-purpose processor for a highly repetitive mathematical task?
(A) Overall system reprogrammability
(B) Execution speed and power efficiency
(C) Availability of debugging tools
(D) High-level software portability

2003

15. In IC technologies, what does the term ASIC stand for?
(A) Application-Specific Integrated Circuit
(B) Asynchronous System Interconnect Controller
(C) Automated Software Implementation Chip
(D) Analog-to-Serial Interface Component

2021

16. What is the primary disadvantage of full-custom VLSI design compared to using Programmable Logic Devices (PLDs)?
(A) Full-custom VLSI consistently consumes significantly more static power
(B) Full-custom VLSI typically results in a much larger silicon chip area
(C) Full-custom VLSI has very high NRE costs and development times
(D) Full-custom VLSI inherently offers much lower overall execution speeds

2002

17. Which of the following best describes an FPGA?
(A) A processor with a rigid instruction set that cannot be altered or updated
(B) A pure software-based emulation of physical digital hardware components
(C) An analog filter circuit designed exclusively for high-frequency signals
(D) A chip with configurable logic blocks and programmable interconnects

NODIA

2002

18. When used in digital design, when would a designer most likely choose a CPLD over an FPGA?
(A) When implementing highly complex algorithms requiring millions of gates
(B) When the system demands massive capacities

files

2024

56. Which data transfer type in USB is designed for time-sensitive data where occasional data loss is acceptable, such as audio streaming?
(A) USB Control Transfer
(B) USB Bulk Transfer
(C) USB Interrupt Transfer
(D) USB Isochronous Transfer

2023

57. Which technology relies on the transmission of light pulses outside the visible spectrum for short-range communication?
(A) Wi-Fi technology
(B) IrDA (Infrared Data Association) technology
(C) Bluetooth system
(D) Zigbee standards

2001

58. The IEEE 802.11 (Wi-Fi) standard defines operations in which layers of the OSI model?
(A) Network and Transport OSI layers
(B) Application and Presentation layers
(C) Physical and Data Link OSI layers
(D) Session and Presentation OSI layers

2023

59. Which wireless standard utilizes a frequency-hopping spread spectrum (FHSS) technique to mitigate interference in the 2.4 GHz ISM band?
(A) Infrared IrDA standard
(B) Amplitude Modulation radio
(C) Standard Ethernet protocol
(D) Bluetooth wireless standard

2003

60. Consider the assertion and reason statements below regarding Infrared Data Association (IrDA) technology.
Assertion (A): IrDA is highly secure against eavesdropping compared to omnidirectional wireless protocols like Wi-Fi.
Reason (R): IrDA relies on line-of-sight communication with a narrow beam angle, requiring close physical proximity and direct alignment.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

61. In a Bluetooth piconet, what is the maximum number of active secondary (slave) devices that can communicate simultaneously with the primary (master) device?
(A) 3
(B) 7
(C) 15
(D) 255

2015

62. Which component of a Real-Time Operating System (RTOS) is fundamentally responsible for CPU time allocation among competing tasks?
(A) The File System
(B) The Kernel Scheduler
(C) The Device Driver
(D) The Command Line Interface

2025

63. When an RTOS task is waiting for a hardware interrupt or a shared resource to become available, it is in which state?
(A) Blocked state
(B) Running state
(C) Ready state
(D) Stopped state

2016

64. What happens during a context switch in an RTOS?
(A) The kernel dynamic memory allocator reorganizes the heap to prevent fragmentation
(B) The executing RTOS switches from real-time mode to general-purpose mode
(C) Active task state is saved, and the next ready task state is loaded
(D) The CPU switches from using a Harvard architecture to a Von Neumann architecture

2008

65. Which of the following contributes most significantly to the "context switch latency" in an embedded system?
(A) The time required to clear physical caching registers on the network card
(B) The time taken by the scheduler to resolve memory access conflicts on the external bus
(C) The hardware propagation delay of the system clock signal
(D) Saving and restoring CPU registers to and from the task control block

Click Here to Buy book on Flipkart

into assembly instructions
(D) To generate signals that direct data flow through the datapath

2025
28. Which of the following is a common architectural model for designing a control unit?
(A) Algorithmic State Machine with Datapath (ASMD)
(B) Content-Addressable Memory (CAM)
(C) Instruction Register Pipeline (IRP)
(D) Direct Memory Access Controller (DMAC)

2019
29. If a custom single-purpose processor requires faster execution of an iterative addition process, which hardware optimization is most appropriate?
(A) Implementing a shift register mechanism instead of a standard adder unit
(B) Utilizing spatial parallelism or hardware multipliers in the datapath
(C) Replacing the combinational adder with a high-capacity dynamic RAM block
(D) Decreasing the main system clock frequency during heavy computational cycles

2003
30. Consider the statements below regarding datapath and control unit design.
I. The datapath handles data manipulation while the control unit dictates the sequencing.
II. A single monolithic block combining both datapath and control simplifies testing and verification.
III. Control units can be implemented using hardwired logic or microprogrammed architectures.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I only

2010
31. Which optimization technique is most effective for reducing dynamic power consumption in a custom processor?
(A) Clock gating to disable inactive functional blocks
(B) Increasing the supply voltage
(C) Using purely bipolar junction transistors
(D) Running the processor at its maximum possible clock speed continuously

2009
32. How does loop unrolling affect a custom processor's hardware implementation?
(A) It significantly reduces the overall physical size of the datapath
(B) It increases processing time by introducing sequential branch steps
(C) It increases hardware area but enables parallel execution
(D) It completely eliminates the core requirement for a clock signal

2014
33. What is the effect of pipelining on the clock performance of a processor?
(A) It significantly decreases the cumulative instruction throughput of the core
(B) It completely eliminates instruction hazards and execution-stage stalls
(C) It reduces the physical count of logic gates and registers required
(D) It enables a higher clock frequency by reducing critical path delay

2005
34. Which optimization strategy focuses on minimizing the physical footprint of an IC?
(A) Implementing fully parallel hardware multipliers for arithmetic operations
(B) Using standard high-level software compilers without hardware synthesis
(C) Sharing functional units like ALUs across different machine states
(D) Increasing the number of instruction pipeline stages up to twenty

2003
35. What is the impact of utilizing a lower supply voltage on a CMOS circuit?
(A) It significantly increases both cumulative power consumption and raw speed
(B) It quadratically decreases dynamic power but increases propagation delay
(C) It has no measurable effect on power but drastically reduces active silicon area
(D) It completely eliminates static subthreshold leakage current from the design

2025
36. Which structural component is responsible for holding the address of the next instruction to be executed in a general-purpose processor?
(A) Instruction Register (IR)
(B) Arithmetic Logic Unit (ALU)
(C) Memory Data Register (MDR)
(D) Program Counter (PC)

Downloaded from www.pdf.tube

of onboard volatile memory
(C) When requiring predictable, deterministic timing for simpler logic functions
(D) When developing and testing a custom real-time operating system kernel

2006
19. A semi-custom ASIC typically utilizes which of the following methodologies?
(A) Hand-routing every individual transistor
(B) Using standard cell libraries and pre-characterized logic gates
(C) Using purely software-based execution without physical logic gates
(D) Configuring SRAM-based logic blocks at system boot time

2001
20. Match the IC technologies in List I with their characteristic features in List II.
List I: (IC Technology)
P. Full-custom VLSI
Q. Semi-custom ASIC
R. FPGA
S. CPLD
List II: (Characteristic Feature)
1. Uses standard cell libraries to reduce design time compared to manual layout
2. Field-programmable, suited for complex logic, often SRAM-based
3. Highest performance and smallest size, but highest NRE cost
4. Predictable timing, non-volatile, typically used for simpler control logic
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

2017
21. At the Register-Transfer (RT) level, digital system design is primarily described in terms of:
(A) Data flow between registers and logical operations on that data
(B) Physical transistor layouts and standard cell geometrical shapes
(C) High-level software algorithms fully independent of hardware layouts
(D) Printed circuit board physical traces and overall thermal dissipation

2010
22. Which of the following is a fundamental component of combinational logic design?
(A) Flip-flops
(B) Memory arrays
(C) Multiplexers
(D) Program counters

2022
23. What distinguishes sequential logic from combinational logic?
(A) Sequential logic uses memory elements to store past states
(B) Sequential logic output depends entirely on the current inputs
(C) Combinational logic uses clock signals for timing synchronization
(D) Sequential logic cannot be directly implemented on a standard FPGA

2008
24. Which basic sequential component is typically used to build a register?
(A) Full Adder
(B) Decoder
(C) Logic Inverter
(D) D Flip-Flop

2002
25. In RT level design, what is the function of a Finite State Machine (FSM)?
(A) To increase the overall clock frequency of the system
(B) To sequence control signals based on states and inputs
(C) To execute complex floating-point mathematical equations
(D) To store bulk user applications and data files permanently

2002
26. The datapath of a custom single-purpose processor primarily consists of:
(A) Dedicated instruction fetch logic and hardware decoders
(B) Operating system kernel scheduling and routine execution
(C) Execution units like ALUs, multipliers, and registers
(D) Integrated wireless communication transmitter architectures

2017
27. What is the primary role of the control unit in a custom processor?
(A) To perform complex mathematical and logical operations on input data
(B) To store the physical memory addresses of instruction operands
(C) To translate high-level software source code

NODIA

(A) A shared physical hardware clock line
(B) Pre-agreed baud rates and framing bits
(C) A centralized software network switch
(D) Real-time external GPS timing signals

2011

47. Which of the following best describes the RS-232 standard?
(A) A single-ended standard for asynchronous serial transmission
(B) A high-speed, optical-fiber networking protocol standard
(C) A differential signaling standard used for long-distance runs
(D) A wireless network standard for short-range communication systems

2021

48. What is the primary advantage of RS-422 and RS-485 over RS-232?
(A) They use single-ended signaling paths to reduce the physical wire count
(B) They are strictly designed for high-frequency wireless data transmissions
(C) They use differential signaling, offering better noise immunity
(D) They interface directly with USB hardware without standard transceivers

2023

49. Which serial interface standard naturally supports multi-point (multi-drop) topologies allowing multiple drivers and receivers on the same bus?
(A) UART
(B) RS-232
(C) Point-to-point SPI (Serial Peripheral Interface)
(D) RS-485

2016

50. Consider the statements below regarding basic serial communication.
I. UART requires a shared clock line for asynchronous transmission.
II. RS-232 logic levels are strictly between 0V and +5V.
III. RS-485 is a half-duplex standard by default when using a two-wire configuration.
IV. Parity bits in UART are used for complex error correction mechanisms.
V. Baud rate denotes the number of symbol changes per second.
Identify the INCORRECT combination of statements.
(A) I, II and IV
(B) III and V
(C) II, IV and V
(D) I, III and V

2007

51. The USB (Universal Serial Bus) architecture is fundamentally based on which topology?
(A) Token ring network
(B) Tiered star topology
(C) Mesh network setup
(D) Serial daisy chain

2022

52. In the USB protocol, what is the role of an endpoint?
(A) It is the physical connector situated at the end of a serial cable
(B) It is the low-level system driver installed on the host hardware unit
(C) It is a passive termination resistor placed at the end of the bus line
(D) It is a part of a USB device that acts as a source or sink of data

2023

53. Which IEEE standard corresponds to the Firewire interface?
(A) IEEE 802.3
(B) IEEE 802.11
(C) IEEE 802.15.4
(D) IEEE 1394

2004

54. What is a defining characteristic of the Ethernet protocol (IEEE 802.3)?
(A) It relies on sequential token passing protocols for medium access
(B) It operates strictly as a wireless data transmission standard
(C) It uses CSMA/CD mechanisms in half-duplex operating modes
(D) It guarantees absolute deterministic timing for real-time systems

2013

55. Unlike standard USB, IEEE 1394 (Firewire) inherently supports which of the following features?
(A) Direct peer-to-peer transfers without a host controller
(B) Wireless data transmission extending up to ten meters
(C) Single-wire physical line half-duplex communication
(D) Native, direct execution of software binary

Click Here to Buy book on Amazon

(B) It causes fragmentation and non-deterministic execution times
(C) It consumes excessively large pools of scarce on-chip static RAM
(D) It is completely unsupported by standard ANSI C cross-compilers

2022
94. To avoid the drawbacks of standard dynamic memory allocation, what strategy do many RTOSs employ?
(A) Forbidding dynamic data storage in physical RAM
(B) Fixed-size memory block partitions (Memory Pools)
(C) Storing all volatile runtime variables in EEPROM
(D) Relying entirely on background garbage collectors

2002
95. Which technique is a common power-saving strategy implemented by an RTOS during the Idle Task?
(A) Placing the CPU in a low-power sleep mode until the next interrupt
(B) Entering an active infinite loop to keep the core spinning
(C) Running continuous, heavy background software security scans
(D) Raising operating voltages to finish DMA operations faster

2019
96. Dynamic Voltage and Frequency Scaling (DVFS) saves power by:
(A) Powering down all integrated peripheral devices on a permanent basis
(B) Converting waste thermal heat directly back into electrical energy
(C) Dynamically adjusting frequency and voltage based on execution workloads
(D) Using floating-point computational mathematics instead of integer math

2025
97. The µC-OS (MicroC/OS) kernel is primarily known for being:
(A) A monolithic desktop-oriented, general-purpose operating system
(B) A strictly cooperative, non-preemptive task scheduling engine
(C) A Linux-derived high-level graphical user interface framework
(D) A portable, ROMable, preemptive real-time multitasking kernel

2014
98. How does RT-Linux achieve hard real-time performance alongside a standard Linux environment?
(A) Compiling the entire Linux operating system code base in assembly
(B) Removing all networking, file system, and protocol stacks from Linux
(C) Running standard Linux as a low-priority task under a real-time kernel
(D) Hosting and running standard Linux tasks on a separate remote server

2009
99. Which of the following is a primary characteristic of Embedded Linux?
(A) It demands highly expensive, proprietary licensing fees for each deployed unit
(B) It is open-source, highly customizable, and supports multiple architectures
(C) It is engineered solely for ultra-low-power 8-bit microcontrollers with 1KB RAM
(D) It guarantees microsecond-level hard deterministic timing bounds out of the box

NODIA

2018
100. Consider the statements below regarding embedded operating system characteristics.
I. µC-OS relies on a static array of task control blocks based on priority levels.
II. Windows CE was a preemptive, hard real-time OS designed for handheld and embedded devices.
III. Standard Linux relies on a completely deterministic scheduler suitable for hard real-time avionics.
IV. RT-Linux intercepts hardware interrupts to ensure real-time tasks execute before the standard Linux kernel processes them.
V. Both Embedded Linux and Windows CE offer extensive support for graphical user interfaces (GUIs).
Identify the INCORRECT combination of statements.
(A) I and III
(B) III only
(C) II and IV
(D) I, IV and V

2002
101. What is the fundamental purpose of a cross-compiler in embedded system development?
(A) Compiling source code on a host to run on a

2021

66. A Task Control Block (TCB) in an RTOS generally does NOT contain which of the following?
(A) Assigned task priority levels
(B) Task memory stack pointers
(C) The compiled binary instructions of the task
(D) Current run state of the task

2009

67. Which scheduling algorithm strictly executes tasks to completion without allowing a higher priority task to interrupt them?
(A) Preemptive Priority Scheduling
(B) Non-preemptive (Cooperative) Scheduling
(C) Round-Robin Scheduling with time slicing
(D) Earliest Deadline First (EDF) in preemptive mode

2016

68. In Rate Monotonic Scheduling (RMS), how are static priorities assigned to tasks?
(A) Tasks with longer execution runs get higher priorities
(B) Priority levels are assigned randomly during system bootup
(C) The task arriving first is given top execution priority
(D) Tasks with shorter periods receive higher priorities

2008

69. Earliest Deadline First (EDF) is an example of what type of scheduling?
(A) Dynamic priority scheduling
(B) Static priority scheduling
(C) Cooperative non-preemptive scheduling
(D) First-Come, First-Served scheduling

2008

70. Match the scheduling algorithms in List I with their characteristic features in List II.
List I: (Scheduling Algorithm)
P. Rate Monotonic (RM)
Q. Earliest Deadline First (EDF)
R. Round-Robin (RR)
S. First-Come, First-Served (FCFS)
List II: (Characteristic Feature)
1. Dynamic priority based on proximity to absolute deadline
2. Fixed static priority based on task periodicity
3. Non-preemptive, executes in order of arrival
4. Preemptive, assigns equal time slices sequentially
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-3, R-4, S-1

2024

71. What is the defining requirement of a hard real-time scheduling mechanism?
(A) It must guarantee that all task deadlines are met
(B) It must maximize overall average data throughput
(C) It must provide a responsive graphical user interface
(D) It must run exclusively on multi-core processor systems

2013

72. What is an Interrupt Service Routine (ISR)?
(A) A background software task that continuously polls hardware input ports
(B) A kernel software block executed by the OS during a system crash event
(C) A hardware diagnostic routine run exclusively during the system boot cycle
(D) A function triggered to handle an asynchronous event immediately

2018

73. Which of the following defines "interrupt latency"?
(A) The cumulative processor execution time taken by the entire ISR
(B) The delay from interrupt request to the start of the ISR
(C) The scheduling time required for any active task to yield the CPU
(D) The physical transit delay of electrical control signals on the board

2007

74. What is interrupt nesting?
(A) Storing pending interrupts in a deep software queue for sequential runs
(B) Disabling all physical interrupts to process critical sections of code
(C) A higher-priority interrupt preempting a lower-priority ISR
(D) Placing multiple system interrupt vectors into contiguous RAM areas

2019

75. To minimize interrupt latency in a critical hard real-time system, a designer should:
(A) Make physical ISRs as long and structurally complex as possible
(B) Disable global interrupts for long, extended periods in user code

Downloaded from www.pdf.tube

2025

37. In an instruction pipeline, what happens during the 'Instruction Decode' stage?
(A) The opcode is analyzed and register operands are fetched
(B) The executing processor writes calculation results back to memory
(C) The target machine instruction is fetched from the system cache
(D) Complex mathematical and logical operations are done on the data

2009

38. What is a "data hazard" in the context of instruction pipelining?
(A) An overlap of read and write cycles leading to physical RAM damage
(B) Noise interference on physical data lines causing logical signal corruption
(C) A delay because an instruction depends on a previous unfinished result
(D) A critical application software bug that results in an infinite loop

2021

39. How do general-purpose processors typically resolve control hazards caused by branch instructions?
(A) Using branch prediction and delayed branching
(B) Inserting static delay states into every mathematical instruction
(C) Ignoring the branching path to run sequentially
(D) Converting all branching statements into interrupts

2007

40. Consider the statements below regarding processor architectures.
I. Von Neumann architecture uses separate memory spaces for data and instructions.
II. Harvard architecture allows simultaneous fetching of data and instructions.
III. General-purpose processors always avoid pipelining to maintain simplicity.
IV. The ALU is a core component of the execution stage.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) II, III and IV
(C) I and IV
(D) II and IV

2018

41. What is the defining characteristic of a Digital Signal Processor (DSP) compared to a standard microcontroller?
(A) DSPs entirely lack any on-chip non-volatile flash memory storage
(B) DSPs are optimized for rapid Multiply-Accumulate math operations
(C) DSPs are engineered strictly to handle low-speed analog control loops
(D) DSPs cannot establish interfaces with typical external system peripherals

2002

42. Which ASIP feature enables executing a multiplication and an addition in a single clock cycle?
(A) Watchdog timer
(B) Pulse Width Modulation (PWM) generator
(C) Hardware MAC unit
(D) Serial Peripheral Interface (SPI)

2007

43. Why are microcontrollers typically preferred over microprocessors for simple embedded control applications?
(A) They run complex desktop-oriented operating systems flawlessly
(B) They operate at maximum physical clock speeds exceeding five gigahertz
(C) They inherently consume high amounts of electrical power for integrity
(D) They integrate CPU, memory, and peripherals on a single chip

2004

44. Which architectural feature is heavily utilized in DSPs to maintain rapid data throughput without tying up the main CPU?
(A) Direct Memory Access (DMA)
(B) Virtual Memory Paging
(C) Deep Sleep Modes
(D) Graphical Processing Units (GPUs)

NODIA

2001

45. Which memory architecture is predominantly found in DSPs to facilitate multiple simultaneous memory accesses?
(A) Strictly Von Neumann architecture
(B) Modified Harvard architecture
(C) Single-port dynamic RAM architecture
(D) Synchronous sequential register stack

2023

46. What does the UART protocol rely on to synchronize the transmitter and receiver?

event conditions simultaneously
(B) Transferring very large, multi-megabyte data files directly between active tasks
(C) Managing dynamic priority reallocation in cooperative scheduling
(D) Storing hardware execution states during critical system power-down

2018

86. How do Signals function in embedded IPC?
(A) They are active hardware voltage levels on physical GPIO pins
(B) They are used to halt the physical CPU clock line to save power
(C) They are software interrupts notifying a process of an event
(D) They guarantee robust delivery of very large software payloads

2015

87. Unbounded Priority Inversion is a catastrophic scheduling anomaly where:
(A) A high-priority task waiting for a resource held by a low-priority task is indirectly blocked by medium-priority tasks preempting the low-priority task.
(B) A high-priority task continuously preempts and starves low-priority tasks due to a lack of round-robin time slicing.
(C) A task's priority is dynamically increased beyond the kernel's allowed limit, causing stack corruption.
(D) The scheduler enters an infinite loop while trying to resolve nested interrupt requests.

2006

88. How does the Priority Inheritance Protocol (PIP) address priority inversion?
(A) It forces the active high-priority task to yield the processor to other waiting tasks
(B) It lowers the relative priorities of all medium-priority tasks to the lowest level
(C) It automatically terminates the resource-holding low-priority task immediately
(D) It temporarily raises the resource-holding low-priority task's priority to match the priority of the highest-priority task waiting for that resource.

2011

89. Which weakness of the standard Priority Inheritance Protocol is resolved by the Priority Ceiling Protocol (PCP)?
(A) PCP reduces the static memory footprint of the RTOS kernel
(B) PCP prevents chain blocking and deadlocks from nested resources
(C) PCP allows ISRs to access global variables without any lockouts
(D) PCP eliminates the actual need for an RTOS scheduler algorithm

2023

90. Consider the statements below regarding the Priority Ceiling Protocol (PCP).
I. Every resource is assigned a priority ceiling equal to the highest priority of any task that may lock it.
II. A task can acquire a lock only if its current priority is strictly higher than the priority ceilings of all locks currently held by other tasks.
III. PCP guarantees that priority inversion is bounded to at most one critical section execution.
IV. PCP relies on tasks yielding CPU voluntarily using delay functions.
Which of the above statement(s) is/are correct?
(A) I, II and III
(B) II, III and IV
(C) I, III and IV
(D) I and II

2013

91. The Mars Pathfinder mission (1997) experienced systemic resets due to which specific RTOS scheduling anomaly?
(A) Stack Overflow
(B) Deadlock
(C) Memory Fragmentation
(D) Priority Inversion

2002

92. An embedded software timer is fundamentally implemented using:
(A) A hardware timer driving a software tick counter within the RTOS
(B) The processor's internal Arithmetic Logic Unit execution cycles
(C) A dedicated, high-precision external atomic clock reference chip
(D) Mechanical quartz crystal resonators connected directly to physical GPIOs

2017

93. Dynamic memory allocation (e.g., `malloc()`) is often discouraged in hard real-time systems primarily because:
(A) It relies on virtual memory schemes requiring local physical storage

Click Here to Buy book on Flipkart

(C) Rely solely on continuous hardware polling instead of interrupts
(D) Keep ISRs extremely short and defer heavy processing to tasks

2012
76. In processor architecture, what is an interrupt vector?
(A) A memory address pointing to the start location of the target ISR
(B) The physical hardware copper trace carrying raw interrupt signals
(C) A mathematical vector value linked with the system priority scheme
(D) The on-chip hardware register containing active interrupt status flags

2015
77. What is a binary semaphore primarily used for in an embedded system?
(A) Managing dynamic memory allocation on the system heap
(B) Mutually exclusive access to a single resource
(C) Enabling direct memory access transfers between peripherals
(D) Performing high-speed arithmetic operations in the ALU

2010
78. How does a counting semaphore differ from a binary semaphore?
(A) It is restricted to counting clock cycles within a hardware timer
(B) It can take any non-negative integer to manage multiple resources
(C) It is a restricted primitive that can only be accessed by the kernel
(D) It automatically increments its value at fixed millisecond intervals

2016
79. Which IPC mechanism inherently provides priority inheritance to solve the priority inversion problem?
(A) Mutex (Mutual Exclusion object)
(B) Counting Semaphore Primitive
(C) Shared Global Memory Variable
(D) RTOS Kernel Software Timer

2005
80. Consider the statements below regarding synchronization primitives.
I. A Mutex is generally owned by the task that acquires it, meaning only that task can release it.
II. A binary semaphore can be signaled (released) by an ISR.
III. Spinlocks are preferable over blocking Mutexes in single-core processors for long resource holds.
Which of the above statement(s) is/are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2025
81. Which problem occurs when two tasks hold locks on separate resources and each waits indefinitely for the other's resource?
(A) Livelock
(B) Priority Inversion
(C) Thrashing
(D) Deadlock

NODIA

2003
82. Which advanced IPC mechanism is best suited for sending a structured block of data between two distinct tasks?
(A) Event Register
(B) Binary Semaphore
(C) Message Queue
(D) Mutex

2022
83. What is a key characteristic of a Mailbox in RTOS IPC?
(A) It operates strictly as a Last-In, First-Out (LIFO) data stack structure
(B) It holds a single message or pointer to allow rapid data exchange
(C) It relies on hardware direct memory access to bypass the CPU
(D) It can only transfer encrypted float-point arrays

2023
84. In Unix-like RTOS environments, what is a Pipe primarily used for?
(A) Managing low-level graphical rendering pipelines for user interfaces
(B) Allocating dynamic heap memory segments within the active kernel space
(C) Managing asynchronous hardware interrupt lines and prioritize requests
(D) Unidirectional byte-stream communication between related processes

2001
85. Event Registers (or Event Flags) are highly efficient for which scenario?
(A) Synchronizing tasks with multiple discrete

different target architecture
(B) Compiling code written in multiple software languages into a single binary
(C) Translating assembly-level instructions directly back into high-level C code
(D) Automatically fixing critical syntax and compiler errors across raw files

2003

102. Which embedded software tool is responsible for combining various object files and resolving memory addresses to produce a single executable image?
(A) Preprocessor
(B) Cross-compiler
(C) Linker
(D) Profiler

2022

103. What is the primary function of an absolute loader in an embedded system?
(A) It loads executable code into a predefined, fixed memory location
(B) It downloads software binaries from remote servers during runtime execution
(C) It relocates absolute memory addresses dynamically whenever the hardware boots
(D) It encrypts compiled firmware code to protect user intellectual property

2014

104. Which debugging tool allows a developer to set breakpoints, inspect CPU registers, and step through code directly on the target hardware without modifying the application code?
(A) High-speed hardware Logic Analyzer
(B) Software-based printf debug statements
(C) Physical high-bandwidth Oscilloscope
(D) JTAG Debugger or In-Circuit Emulator

2021

105. In a typical GCC toolchain, the output file that contains machine code with unresolved external symbols is:
(A) Executable file (.exe)
(B) Object file (.o)
(C) Map file (.map)
(D) Hex file (.hex)

2004

106. In the hardware synthesis hierarchy, Logic Synthesis refers to the process of:
(A) Converting high-level algorithms to RT-level structural models
(B) Automatically routing physical copper trace lines on a multilayer PCB
(C) Translating behavioral HDL models into optimized gate-level netlists
(D) Deriving truth tables and minimizing functions using Karnaugh maps

2022

107. Register-Transfer (RT) synthesis primarily bridges the gap between:
(A) Gate-level logic networks and physical transistor-level layouts
(B) High-level software routines and physical memory architectures
(C) Standard network packet protocols and low-level device drivers
(D) Behavioral states/datapaths and structural gate models

2009

108. Behavioral Synthesis (or High-Level Synthesis) accomplishes which of the following?
(A) Converts high-level algorithms directly into RTL hardware designs
(B) Translates Boolean equations and truth tables into basic logic gates
(C) Maps physical CMOS transistor models directly onto silicon wafers
(D) Optimizes assembly instructions for a specific target hardware core

NODIA

2023

109. Which phase of logic synthesis involves mapping the optimized boolean network to a specific manufacturer's standard cell library?
(A) Technology-independent optimization
(B) Technology mapping
(C) Placement and Routing (P&R)
(D) State encoding

2025

110. Consider the assertion and reason statements below regarding High-Level Synthesis (HLS) in hardware design.
Assertion (A): High-Level Synthesis (HLS) significantly reduces the time-to-market for complex custom hardware accelerators.
Reason (R): HLS allows designers to explore architectural trade-offs (like unrolling loops or pipelining) at a higher level of abstraction, rather than rewriting complex RTL code manually.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

(D) Generate stable high-frequency clock signals for synchronous logic

2025

148. In sequential logic, the minimum time the input signal must be stable before the active clock edge is known as:
(A) Hold time
(B) Propagation delay
(C) Rise time
(D) Setup time

2006

149. What occurs if the setup or hold time constraints of a flip-flop are violated?
(A) The register triggers an automatic system interrupt
(B) The device enters metastability with unstable outputs
(C) The logical outputs are permanently inverted
(D) The gate-level propagation delay drops to zero

2015

150. Consider the following statements about RT level design:
I. The critical path delay dictates the maximum operating frequency of a digital circuit.
II. Pipelining increases the overall critical path delay.
III. A Moore machine's outputs depend only on the current state.
IV. A Mealy machine's outputs depend on the current state and current inputs.
V. Resource sharing always decreases the critical path delay.
Which of the above statements are correct?
(A) I, III and IV
(B) II, IV and V
(C) I, II and III
(D) III, IV and V

2018

151. An Algorithmic State Machine (ASM) chart differs from a standard state diagram primarily by:
(A) Using high-level software constructs rather than hardware descriptions
(B) Describing completely asynchronous logic paths with no clock references
(C) Omitting conditional branching paths based on external inputs
(D) Defining state transitions and datapath steps synchronously

2010

152. Which component converts the current state and inputs into the next state in a finite state machine?
(A) Next-state combinational logic
(B) Output-generation logic block
(C) State memory flip-flop array
(D) Data storage register banks

2024

153. A processor executing DSP algorithms relies heavily on a MAC unit. What does MAC stand for?
(A) Memory Access Controller
(B) Multiply and Accumulate
(C) Media Access Control
(D) Multiplexed Arithmetic Center

2007

154. To optimize for size (area), a custom single-purpose processor might:
(A) Unroll all iterative loops to eliminate branching overhead
(B) Share a single ALU across clock cycles to reduce physical silicon area
(C) Implement separate hardware adders for each loop execution
(D) Utilize parallel barrel shifter logic networks exclusively

2007

155. Which of the following directly defines the "critical path" in a digital circuit?
(A) The logic path with the maximum delay between two registers
(B) The shortest routing path connecting any two system registers
(C) The thickest physical trace carrying the power supply current
(D) The distribution network carrying the master clock signal

2022

156. In instruction pipelining, a "structural hazard" occurs when:
(A) An instruction requires an operand produced by a preceding instruction not yet finished
(B) A branch instruction changes the program counter unexpectedly
(C) Two instructions require the use of the same hardware resource simultaneously
(D) The clock frequency exceeds the maximum limit of the critical path

Downloaded from www.pdf.tube

S. In-Circuit Testing

List II: (Description)

1. Uses test benches and vectors to observe signal changes over time
2. Uses physical programmable logic (like FPGA arrays) to prototype the design for fast verification
3. Probes the physical PCB to verify component placement and solder integrity
4. Uses mathematical algorithms to prove functional properties hold true for all states

(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-1, R-2, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-2, Q-1, R-4, S-3

2007

121. Design automation tools (EDA) are essential in modern embedded system design primarily because:
(A) They write complex application software and algorithms automatically
(B) Manual layout and routing cannot handle modern system complexity
(C) They guarantee that the compiled code will run on any target processor without profiling
(D) They synthesize optimal analog filter components from pure software algorithms

2010

122. In the context of SoC (System on Chip) design, what is an IP (Intellectual Property) core?
(A) The physical, registered patent document filed with the government
(B) A standardized legal framework and contract for software licensing
(C) A pre-designed, reusable block used to build complex SoC designs
(D) A dedicated hardware unit that encrypts outgoing internet traffic

2009

123. A Soft IP core is typically provided in which format?
(A) A finished, fabricated physical chip
(B) A low-level GDSII physical layout file
(C) A pre-compiled C++ application binary
(D) Synthesizable VHDL or Verilog RTL code

2001

124. Which of the following is a characteristic of a Hard IP core?
(A) It is a fixed layout mapped to a technology, guaranteeing timing
(B) It offers maximum flexibility to modify internal logic configurations
(C) It is portable across various fabrication foundries and system nodes
(D) It is typically written purely in high-level application C software

NODIA

2008

125. The concept of "design reuse" in embedded systems directly contributes to optimizing which primary design metric?
(A) Maximum operating battery voltage
(B) Development cost and time-to-market
(C) Total clock cycles per instruction
(D) Overall physical weight of the product

2023

126. Which standard protocol is commonly used as an on-chip bus architecture to interconnect various IP cores in an SoC?
(A) Peripheral Component Interconnect Express (PCIe)
(B) Advanced Microcontroller Bus Architecture (AMBA)
(C) Controller Area Network (CAN bus)
(D) Ethernet (IEEE 802.3)

2003

127. Which of the following best describes Firm IP?
(A) A synthesized netlist combining Soft IP flexibility and Hard IP predictability
(B) IP cores provided strictly as technology-specific GDSII physical layout files
(C) IP modules provided as raw synthesizable RTL source code with no constraints
(D) An IP core implemented strictly within volatile memory registers that cannot be powered down.

2012

128. What is a "testbench" in the context of hardware design automation?
(A) A physical array of logic analyzers used to measure real-time waveforms
(B) A regression software suite that measures execution latency of final binaries
(C) An HDL environment applying stimuli to a design and verifying responses
(D) A hardware diagnostic routine run during the IC packaging stage

2016

129. How does the integration of Commercial Off-The-Shelf (COTS) components impact system design?
(A) It significantly increases total time required for system design

(B) It restricts the target design to run solely on analog signals
(C) It guarantees absolute zero bugs or defects in final products
(D) It reduces time and cost by using standardized components

2014
130. Consider the statements below regarding real-time embedded systems.
I. A missed deadline in a soft real-time system causes degraded performance but not catastrophic failure.
II. Hard real-time systems always require multi-core processors.
III. Predictability and determinism are more critical than absolute peak throughput in real-time systems.
Which of the above statement(s) is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I only

2016
131. Which of the following accurately describes "Jitter" in the context of real-time embedded systems?
(A) The physical time taken by a compiler to build the application
(B) The timing variation or deviation of a periodic execution event
(C) The latency introduced when switching between operating systems
(D) The noise margin degradation over differential signaling lines

2013
132. What is the defining characteristic of a "Reactive" embedded system?
(A) It performs non-real-time batch data processing calculations overnight
(B) It initiates physical chemical reactions to power up the computer core
(C) It interacts with human users through a physical interface keyboard only
(D) It continuously interacts with and responds to external environmental stimuli

2015
133. When optimizing an embedded system for minimal power consumption, a designer must focus on reducing:
(A) Both dynamic and static power consumption
(B) Only dynamic power consumption
(C) Only static (leakage) power consumption
(D) The system memory bus width down to one bit.

2009
134. Which design metric is defined as the number of tasks completed by the system in a given amount of time?
(A) Latency
(B) Jitter
(C) Throughput
(D) NRE Cost

2008
135. The concept of "Hardware/Software Partitioning" is fundamentally a trade-off between:
(A) Software flexibility and hardware performance
(B) NRE costs and recurring manufacturing costs
(C) Instruction cache sizes and physical register counts
(D) Execution latency and timing jitter of dynamic schedulers

2018
136. A system requires executing an extremely complex cryptographic algorithm with tight energy constraints. Which architecture is generally best suited?
(A) Application-Specific Integrated Circuit
(B) Standard 8-bit Microcontroller Unit
(C) Desktop General-Purpose Processor Unit
(D) General-Purpose Software Interpreter

2009
137. Which processor type uses microcode to implement complex instructions natively within the control unit?
(A) Reduced Instruction Set Computer (RISC) systems
(B) Complex Instruction Set Computer (CISC) systems
(C) Digital Signal Processing (DSP) architectures
(D) Dedicated Single-Purpose Hardware (SPH) designs

2023
138. What is the primary purpose of Cache Memory in general-purpose processors?
(A) To store non-volatile bootstrap instructions permanently
(B) To buffer frequently used data to reduce access latency
(C) To serve as secondary slow-speed storage backup for RAM

Click Here to Buy book on Amazon

(D) To execute arithmetic logic operations directly

2015

139. In a Von Neumann architecture, a bottleneck often arises due to:
(A) Shared single bus and memory path for instructions and data
(B) Separate hardware buses dedicated to instructions and data
(C) The hardware limitation of only supporting 8-bit operations
(D) Mandatory implementation of dynamic branch execution schemes

2014

140. Consider the following statements about processor architectures:
I. ASIPs combine features of both general-purpose processors and custom ASICs.
II. DSPs typically feature hardware zero-overhead looping.
III. Microcontrollers generally lack on-chip peripheral interfaces.
IV. General-purpose processors are optimized for the highest possible performance across a wide variety of unpredicted workloads.
Which of the above statements are correct?
(A) I, II and IV
(B) II, III and IV
(C) I and III
(D) I, II and III

2011

141. The Harvard architecture inherently mitigates which type of pipeline hazard?
(A) Data hazards resulting from register writeback stages
(B) Control hazards originating from branch execution paths
(C) Power hazards triggered by rapid switching activities
(D) Structural hazards caused by concurrent memory accesses

2025

142. A System-on-Chip (SoC) integrates:
(A) Peripheral memory and interface controllers on a dedicated printed circuit board
(B) Multiple individual processor units connected via high-speed serial links
(C) All main system components integrated together on a single silicon die
(D) Voltage regulation circuits and thermal dissipation structures on a single ceramic package

2016

143. Which of the following is true regarding full-custom VLSI design?
(A) It utilizes pre-fabricated standard cell libraries to minimize design time
(B) It enables manual transistor-level layout optimization for efficiency
(C) It features the lowest non-recurring engineering costs in the market
(D) It allows rapid automated circuit generation within several hours time

2023

144. Complex Programmable Logic Devices (CPLDs) are fundamentally based on which architecture?
(A) Look-Up Tables (LUTs) placed within programmable routing channels
(B) Standard cell structures designed using fixed CMOS logic gates
(C) Von Neumann processor cores executing sequential instructions
(D) Macrocells consisting of Sum-of-Products logic and flip-flops

2022

145. FPGAs typically implement combinatorial logic using:
(A) Programmable Look-Up Tables (LUTs)
(B) Hardwired NAND gate logic arrays
(C) Microcoded Read-Only Memory units
(D) Dynamic RAM refresh logic systems

NODIA

2021

146. Which characteristic of SRAM-based FPGAs requires a configuration memory chip (like EEPROM/Flash) on the board?
(A) High logic density requirements during mapping
(B) Slow execution speeds compared to custom ASICs
(C) Volatility; configuration is lost without power
(D) Integrated battery backup circuits on the silicon

2015

147. Multiplexers are widely used in custom processor datapaths to:
(A) Route data from multiple source paths into a single target register
(B) Multiply two binary operands within a single high-speed clock cycle
(C) Increment the internal program counter during the instruction fetch

2002

111. System synthesis in Hardware/Software Co-Design primarily involves which critical decision-making step?

(A) Hardware/Software Partitioning of system tasks
(B) Selecting the exact clock frequency of the memory bus interface
(C) Generating low-level device drivers for standardized peripheral buses
(D) Designing the physical cooling mechanism for high-power packaging

2013

112. Which of the following is a primary goal of Hardware/Software Co-Design?

(A) Designing the target hardware entirely before writing any associated application software
(B) Ensuring application software utilizes 100% of the processor resources at all times
(C) Concurrently designing and optimizing hardware and software to meet constraints
(D) Eliminating the need for underlying operating systems in modern consumer electronics

2003

113. In the context of HW/SW Co-Design, profiling is used to:

(A) Verify the correctness of logic gates using static formal methods
(B) Determine the physical layer protocol of wireless communications
(C) Estimate the total retail cost of the physical integrated circuit components
(D) Identify computationally heavy software code parts for acceleration

2022

114. During HW/SW partitioning, tasks with high computational complexity and strict timing requirements are typically assigned to:

(A) Standard interpreted software languages
(B) Non-real-time background OS threads
(C) Custom hardware blocks or accelerators
(D) Off-chip non-volatile memory storage

2007

115. What role does "co-simulation" play in the Co-Design methodology?

(A) It models the thermal dissipation across multiple PCB layers simultaneously
(B) It runs software on simulated hardware models before physical fabrication
(C) It emulates analog noise interference on high-speed serial interconnects
(D) It models the mechanical stress on the device under high-vibration scenarios

2017

116. System verification is fundamentally concerned with answering which question?

(A) Does the design comply with international environmental disposal regulations?
(B) Is the software optimized to run on any general-purpose architecture?
(C) Does the final product appeal to the targeted consumer demographics?
(D) Did we build the system right per specifications?

2019

117. Which of the following verification techniques mathematically proves that a design meets its specification without requiring explicit test vectors?

(A) Formal verification methods
(B) Simulation-based checking
(C) Physical hardware emulation
(D) In-circuit system debugging

2014

118. What is a key advantage of Hardware Emulation over Software Co-simulation?

(A) It requires absolutely zero physical hardware setup or lab space to operate
(B) It relies entirely on static mathematical proofs rather than active execution
(C) It runs orders of magnitude faster than software simulation for stack testing
(D) It strictly limits system testing and analysis to analog signal behaviors

2019

119. In co-simulation, an Instruction Set Simulator (ISS) is used to:

(A) execute target machine code to evaluate software logic and timing
(B) simulate exact physical heat levels generated within the processor
(C) generate global clock signals for the physical prototyping FPGA
(D) synthesize and optimize the structural gate-level circuit netlist

2009

120. Match the verification techniques in List I with their descriptions in List II.

List I: (Verification Technique)
P. Formal Verification
Q. Logic Simulation
R. Hardware Emulation

Downloaded from www.pdf.tube

2015
157. Which technique is used to resolve data hazards in pipelined processors without stalling the pipeline?
(A) Static Branch Prediction Algorithms
(B) Dynamic Cache Memory Reconfigurations
(C) Clock Gating and Power-Down States
(D) Operand Forwarding (Data Bypassing)

2010
158. What is the fundamental role of a "superscalar" processor architecture?
(A) Executing instructions in a strictly reversed program order
(B) Scaling internal core voltage levels dynamically during run
(C) Issuing multiple instructions to parallel execution units
(D) Operating logic blocks completely without any global clocks

2003
159. Which feature makes microcontrollers particularly suited for deterministic real-time control?
(A) Large virtual memory paging and hardware translation systems
(B) Integrated timer blocks and deterministic interrupt latencies
(C) Out-of-order execution pipelines with dynamic branch systems
(D) Automatic dynamic memory management with garbage collection

2014
160. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Microcontrollers usually employ on-chip Flash memory for program storage rather than external RAM.
Reason (R): Flash memory allows for non-volatile storage, ensuring the embedded control program is retained when the system is powered off.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2013
161. In serial communication, what is "simplex" communication?
(A) Data transmission in only one fixed direction
(B) Data transmission simultaneously in both directions
(C) Data transmission in both directions, but only one direction at a time
(D) Data transmission using multiple parallel wires

2014
162. How does the UART receiver determine where one byte ends and the next begins?
(A) By monitoring a dedicated synchronization clock line continuously
(B) By awaiting a specific start-of-frame escape byte sequence
(C) By timing the Start bit, data bits, and Stop bit sequences
(D) By utilizing physical hardware handshake lines continuously

NODIA

2009
163. The RS-232 interface typically limits transmission distance to approximately 15 meters at standard baud rates due to:
(A) Signal degradation and noise on single-ended physical lines
(B) High-frequency distortion arising from differential signals
(C) Software processing latency within the host operating system
(D) Mechanical size constraints of standard physical DB-9 ports

2023
164. RS-485 achieves robust communication in industrial environments primarily by:
(A) Implementing high-frequency modulation algorithms on carrier waves
(B) Mandating physical optical fiber links between network nodes
(C) Operating strictly on single-ended high-voltage digital lines
(D) Transmitting differential voltage signals over twisted pairs

2014
165. The USB protocol relies on enumeration to:
(A) Count the total number of hardware packets sent across the network
(B) Identify and configure new peripheral devices attached to the bus
(C) Calculate cyclic redundancy check bits for active error detection

(D) Delete corrupted and redundant data storage files from host disks

2023

166. Which type of USB transfer guarantees bandwidth and bounded latency, but does not guarantee error-free delivery?
(A) Bulk
(B) Interrupt
(C) Isochronous
(D) Control

2001

167. IEEE 1394 (Firewire) utilizes a tree topology that is automatically configured upon connection. This process is similar to USB's enumeration but inherently supports:
(A) A restricted network scale with a maximum of four devices
(B) Transmission of high-fidelity analog video streams
(C) Half-duplex communication modes across all connected nodes
(D) Direct Memory Access (DMA) transactions between device nodes

2011

168. In an Ethernet network (IEEE 802.3), what dictates the unique physical identity of a network interface controller (NIC)?
(A) Its hardware-defined 48-bit MAC (Media Access Control) address
(B) Its dynamically assigned 32-bit or 128-bit IP network address
(C) Its subnet mask configuration for dividing regional IP domains
(D) The logical host computer name configured by the network user

2010

169. What was the primary purpose of introducing switches over traditional hubs in Ethernet networks?
(A) To translate wired network signals into wireless radio mediums
(B) To isolate collision domains by routing frames to target ports
(C) To serve as a network-level security firewall blocking malware
(D) To scale up electrical signal voltages for long-distance lines

2003

170. Match the communication protocols in List I with their defining characteristics in List II.
List I: (Communication Protocols)
P. I2C
Q. SPI
R. CAN (Controller Area Network)
S. USB
List II: (Characteristics)
1. Differential bus widely used in automotive systems for robust real-time communication
2. Tiered star topology, host-centric, hot-pluggable
3. Synchronous, multi-master, two-wire (SDA/SCL) bus
4. Synchronous, full-duplex, typically requires separate chip select (CS) lines for each slave
(A) P-3, Q-4, R-1, S-2
(B) P-4, Q-3, R-2, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-3, S-2

2009

171. Infrared Data Association (IrDA) protocols operate primarily in which physical mode?
(A) Half-duplex, line-of-sight, point-to-point transmission
(B) Full-duplex, omnidirectional wireless radio propagation
(C) Multi-point, dynamic self-healing mesh network channels
(D) Differential, noise-immune high-speed wired connections

2014

172. The Wi-Fi standard (IEEE 802.11) uses which mechanism to manage medium access and avoid collisions?
(A) CSMA/CD (Collision Detection)
(B) Token Passing
(C) CSMA/CA (Collision Avoidance)
(D) Time Division Multiple Access (TDMA)

2005

173. Which power-saving mechanism is built into the IEEE 802.11 standard to help mobile devices conserve battery?
(A) Automated transmitter power boosting operations
(B) Continuous high-frequency channel scanning modes
(C) Dynamic core voltage overdriving configurations
(D) Delivery Traffic Indication Message sleep states

Click Here to Buy book on Flipkart

2016

174. Bluetooth establishes basic network links known as Piconets. A group of interconnected Piconets is called a:
(A) Subnet
(B) Wide Area Network
(C) Scatternet
(D) Mesh Ring

2012

175. The kernel architecture of a typical RTOS differs from a general-purpose OS by prioritizing:
(A) High levels of memory protection and virtual address isolation
(B) Full task preemptibility, bounded execution, and low latencies
(C) Optimized graphics processing pipelines for active 3D rendering
(D) Complex file system indexing and background database processing

2021

176. Which state transition occurs when a running RTOS task invokes a delay function (e.g., `TaskDelay(10)`)?
(A) From the Running state to the Ready state
(B) From the Blocked state to the Terminated state
(C) From the Ready state to the Running state
(D) From the Running state to the Blocked state

2019

177. In a non-preemptive RTOS, when does the scheduler switch execution to another task?
(A) When the running task explicitly yields control or blocks
(B) As soon as a higher-priority task enters the ready queue
(C) Every time a periodic hardware timer interrupt is triggered
(D) Only when a critical memory access error occurs

2002

178. In a preemptive priority scheduling system, what happens when an interrupt readies a high-priority task while a low-priority task is running?
(A) The low-priority task continues execution until it fully completes
(B) The scheduler waits until the running task enters the blocked state
(C) The current task context is saved and the ready task runs instantly
(D) The low-priority task is permanently terminated by the kernel

2025

179. Under Rate Monotonic Scheduling (RMS), what is a known limitation regarding processor utilization?
(A) It guarantees scheduling feasibility if total processor utilization is below approximately 69%
(B) It requires all tasks to have identical execution times and periods
(C) It is limited to scheduling a maximum of three concurrent tasks
(D) It requires the task deadlines to be strictly longer than their periods

2004

180. Arrange the following steps of the typical sequence of events during a context switch in a preemptive RTOS:
I. Restore the context (registers) of the newly selected task.
II. Save the context of the currently running task into its TCB.
III. The scheduler selects the highest priority ready task.
IV. A timer tick or interrupt triggers the scheduler.
Which of the following represents the correct sequence?
(A) IV, II, III, I
(B) IV, III, II, I
(C) II, IV, III, I
(D) III, II, IV, I

2013

181. What characterizes a "soft" real-time scheduling policy compared to a "hard" real-time policy?
(A) Soft systems rely on cooperative round-robin task schedules
(B) Missed deadlines are tolerated occasionally, though performance degrades
(C) Soft execution policies do not support preemptive scheduling
(D) Soft real-time systems are incapable of handling hardware interrupts

2014

182. During an Interrupt Service Routine (ISR) in a real-time system, which of the following actions should NOT be performed?
(A) Clearing the hardware interrupt status flag
(B) Modifying a global variable or releasing a semaphore
(C) Calling a blocking RTOS delay function or waiting on a mutex
(D) Reading an input value from a peripheral

Downloaded from www.pdf.tube

register

2015

183. When multiple interrupts occur simultaneously, how does the processor typically determine which ISR to execute first?
(A) By executing the one with the lowest memory address
(B) Random selection
(C) Executing them all simultaneously using multi-threading
(D) Based on a hardware-defined interrupt priority scheme

2025

184. What is the role of a "trampoline" or wrapper function in RTOS interrupt handling?
(A) To manage context switch processes before and after the ISR
(B) To return received data directly back to the transmitter node
(C) To bypass corrupted or faulty instruction blocks in the memory
(D) To boost voltage amplitude of incoming analog sensor inputs

2005

185. A critical section of code in an embedded application is:
(A) A module of software code that consumes the largest amount of RAM memory
(B) A block of code accessing shared resources that needs exclusive execution
(C) A system bootloader routine initializing physical hardware memory banks
(D) A sequence of code that is purely functional with no shared side effects

2018

186. Which method provides the simplest (but often most disruptive) way to protect a critical section in a single-processor embedded system?
(A) Using a binary or counting semaphore structure
(B) Disabling all global interrupts temporarily
(C) Sending messages through a shared Message Queue
(D) Utilizing dynamic heap memory allocation tools

2022

187. What is a "Mutex" essentially?
(A) A binary semaphore supporting ownership and priority inheritance
(B) A dedicated physical integrated circuit for serial communication
(C) A compiler utility used to analyze physical memory map listings
(D) An OS scheduling algorithm designed to run system tasks equally

NODIA

2025

188. Which IPC mechanism is best suited for the Producer-Consumer problem where the producer continuously generates discrete items for the consumer?
(A) Priority Ceiling Protocol
(B) Hardware Interrupt
(C) Message Queue
(D) Unprotected global variable

2022

189. In POSIX-compliant embedded OS environments, what does a "Signal" fundamentally achieve?
(A) Synchronous data transfer operations for large storage files
(B) Permanent hardware locking of the system execution processor
(C) Establishing a dedicated network link using TCP/IP protocols
(D) Asynchronous notification triggering process signal handlers

2012

190. What is the classic Priority Inversion scenario?
(A) A high-priority task is preempted by a low-priority task without any shared resource
(B) A low-priority task dynamically raises its execution priority to prevent preemption
(C) A low-priority task holds a resource needed by a high-priority task, and a medium-priority task preempts the low-priority task
(D) A high-priority task and a medium-priority task run concurrently on a multi-core processor

2019

191. How does the Priority Ceiling Protocol (PCP) differ fundamentally from the Priority Inheritance Protocol (PIP)?
(A) PIP requires prior knowledge of resource usage; PCP does not
(B) PCP prevents deadlocks and chain blocking before blocking occurs
(C) PCP adjusts task priorities statically during compiler operations
(D) PCP is designed for network routing and link scheduling

2008

192. Embedded software timers provided by an RTOS are usually:

(A) More precise than dedicated hardware timers
(B) Accurate to the exact microsecond under any system load
(C) Immune to interrupt latencies and other high-priority task delays
(D) Implemented as software callbacks executed on RTOS tick interrupts

2003

193. Why is memory fragmentation a severe issue in long-running real-time embedded systems?
(A) It causes allocation failures even when total free memory is enough
(B) It corrupts the execution stack of the running task
(C) It causes the physical RAM chip to enter a low-power sleep mode
(D) It corrupts the non-volatile program memory

2011

194. Real-time Memory Management often utilizes "Memory Pools". What are they?
(A) Virtual memory partition sectors swapped directly to hard drives
(B) Cloud-based storage and distributed computing services networks
(C) Pre-allocated blocks of fixed-size memory that can be allocated in constant time
(D) Unstructured heap segments monitored by garbage collection loops

2024

195. Which of the following is an OS-level power saving strategy?
(A) Tickless idle mode suppressing timer ticks when tasks are idle
(B) Continuous polling of active hardware input pins in loop runs
(C) Keeping external LCD backlights permanently on at full power
(D) Disabling high-speed internal cache memory systems

2015

196. µC-OS (MicroC/OS) is characterized as a "ROMable" kernel. This means:
(A) It cannot use any dynamic random-access memory (RAM) during execution
(B) It can only be compiled on systems with optical storage drives
(C) It is designed to run exclusively on hardware containing read-only registers
(D) It can be stored in and executed directly from non-volatile memory (ROM/Flash)

2002

197. In a monolithic embedded OS like Embedded Linux, device drivers typically reside in:
(A) User space
(B) Kernel space
(C) The bootloader
(D) External network servers

2022

198. What approach does RT-Linux use to provide hard real-time capabilities?
(A) It rewrites the entire Linux operating system into one single task
(B) It restricts standard Linux kernels to run only on tiny processors
(C) It runs a microkernel for real-time tasks with Linux in background
(D) It replaces all preemptive Linux features with cooperative scheduling

2009

199. Windows CE (Compact Embedded) was historically known for:
(A) Being an open-source, command-line-only operating system
(B) Disallowing any dynamic heap-based memory allocation
(C) Running only on low-power 8-bit microcontrollers
(D) Providing a familiar Win32 API within a real-time operating system environment

2025

200. Arrange the following steps of an embedded software build process in the correct sequence:
I. Linking object files and libraries
II. Cross-compiling source code to assembly/object code
III. Preprocessing directives and macros
IV. Creating the final executable binary/hex file
Which of the following represents the correct sequence?
(A) III, II, I, IV
(B) II, III, I, IV
(C) III, I, II, IV
(D) I, III, II, IV

2008

201. Which tool is essential for debugging a bare-metal embedded system directly on the target hardware?
(A) A software logic simulator
(B) A JTAG emulator/debugger
(C) A command-line network packet sniffer
(D) An SQL database management system

Click Here to Buy book on Amazon

4. Combines multiple object files and resolves memory addresses

(A) P-2, Q-4, R-1, S-3
(B) P-4, Q-2, R-3, S-1
(C) P-2, Q-4, R-3, S-1
(D) P-1, Q-4, R-2, S-3

2015

221. Which scheduling algorithm calculates priorities dynamically at run-time based on the time remaining until a task's deadline?
(A) Rate Monotonic (RM)
(B) First-Come, First-Served (FCFS)
(C) Fixed-Priority Preemptive
(D) Earliest Deadline First (EDF)

2024

222. An embedded system deployed in a satellite must be primarily evaluated on:
(A) Its compatibility with high-overhead web-based software frameworks
(B) Its visual aesthetics, outer casing shell designs, and color palettes
(C) Its physical volume footprint, power usage, and hardware reliability
(D) The audio sound quality produced by its internal speaker subsystem

2008

223. What is the fundamental advantage of utilizing a Real-Time Operating System (RTOS) over a bare-metal Super-Loop (infinite loop) architecture?
(A) The RTOS requires significantly lower RAM and ROM memory capacities
(B) The RTOS permits deterministic multitasking via preemptive schedules
(C) The RTOS removes requirements for active hardware clock oscillators
(D) The RTOS eliminates the need for any software testing or validation

2006

224. In digital logic, a "combinational" circuit's output is purely a function of:
(A) The previous state of the inputs
(B) The clock frequency
(C) The temperature of the IC
(D) The present state of the inputs

2025

225. A shift register is composed of multiple:
(A) Cascaded flip-flop components sharing clock signals
(B) Hardwired logic AND gate elements arranged in series
(C) Standard electronic multiplexers arranged in parallel
(D) Dedicated analog operational amplifier circuit units

2010

226. What logic is typically used to implement the Arithmetic Logic Unit (ALU) of a processor?
(A) Sequential logic blocks
(B) Passive electronic networks
(C) Combinational logic gates
(D) Operational amplifiers

2011

227. In processor design, what does "instruction pipelining" primarily achieve?
(A) It boosts execution throughput by overlapping instruction phases
(B) It lowers overall latency metrics for single logic instructions
(C) It eliminates the need for cache memory systems
(D) It inherently protects against and prevents all software defects

2013

228. Which of the following defines an Application-Specific Instruction-Set Processor (ASIP)?
(A) A custom design devoid of instructions relying on hardwired gates
(B) Standard high-performance Intel general-purpose processor units
(C) Legacy computer relying on electromagnetic mechanical relay hubs
(D) A processor customized for specialized application class workload

NODIA

2008

229. UART communication is described as "asynchronous" because:
(A) Electrical data streams are limited to one physical wire direction
(B) No shared clock line exists between transmitter and receiver units
(C) Both devices utilize identical synchronized external clock waveforms
(D) High-frequency signal streams are transmitted over wireless mediums

2006

230. Arrange the following steps for establishing a Bluetooth connection in the correct sequence:
I. Paging (Requesting connection)
II. Data Transfer
III. Inquiry (Discovering devices)
IV. Connection Establishment (Service

files from C source code

2025

212. In EDA (Electronic Design Automation), Design Rule Checking (DRC) is performed to:
(A) Verify that software variable names match strict coding style rules
(B) Check for logical and grammatical errors inside product user guides
(C) Automatically assign unique network IP addresses to system elements
(D) Ensure layout patterns meet foundry physical processing constraints

2011

213. What is a "Soft IP Core"?
(A) A physically flexible and bendable silicon microchip
(B) A synthesizable behavioral RTL design in Verilog/VHDL
(C) Pre-compiled software binaries ready for execution run
(D) Purely analog layout designs lacking standard IC gates

2023

214. Which form of IP Core offers the most predictability regarding timing and power consumption?
(A) Synthesizable Soft IP cores
(B) Parameterized Firm IP cores
(C) Hard IP cores (GDSII layouts)
(D) Open-source software C codes

2001

215. The concept of "Code Reuse" in embedded software implies:
(A) Copying and pasting legacy code files without proper structural analysis
(B) Running identical compiled binary executables on distinct target systems
(C) Utilizing old deprecated coding languages to decrease development budgets
(D) Designing reusable, modular software libraries for multiple new systems

2016

216. Which standardized bus architecture is heavily utilized for connecting IP cores within a System-on-Chip (SoC)?
(A) ARM Advanced Microcontroller Bus Architecture
(B) Peripheral Component Interconnect Express bus
(C) Inter-Integrated Circuit synchronous protocol
(D) Recommended Standard 232 serial physical link

2018

217. Hardware/Software Co-Design methodologies emphasize:
(A) Designing hardware and software systems in total isolation from each other
(B) Designing hardware and software in parallel with iterative feedback loops
(C) Designing the hardware fully before writing any software
(D) Using high-overhead software interpreters to bypass hardware constraints

2011

218. When converting a computationally heavy software function to a custom hardware accelerator, one primarily gains:
(A) Decreased raw execution throughput coupled with higher logic flexibility
(B) Higher execution performance and lower power at the cost of flexibility
(C) Reduced physical silicon footprint along with higher engineering costs
(D) Improved software driver portability across distinct operating systems

2001

219. The "Time-to-Market" pressure in embedded systems heavily promotes the use of:
(A) Reusing pre-verified IP cores and commercial off-the-shelf systems
(B) Manual transistor-level placement and full physical silicon routing
(C) Designing proprietary, custom processor architectures for every new project
(D) Writing custom dedicated operating system kernels for each new device

2012

220. Match the software toolchain components in List I with their functions in List II.
List I: (Software Toolchain Components)
P. Cross-Compiler
Q. Linker
R. Loader
S. Debugger
List II: (Functions)
1. Places the final executable into the target memory for execution
2. Translates high-level source code into target-specific object code
3. Allows step-by-step execution and variable inspection on the target

Downloaded from www.pdf.tube

in instruction caches
(D) Hardware manages loop counts and branches with no software overhead

2007
261. How does the CAN (Controller Area Network) bus handle collision resolution when two nodes transmit simultaneously?
(A) By utilizing a token passing method where only the token holder can transmit
(B) By using carrier sense multiple access with collision detection (CSMA/CD) to halt both transmissions
(C) By using non-destructive bitwise arbitration based on message priority identifiers
(D) By letting the host controller dynamically assign transmission time slots to each node

2004
262. USB 2.0 High-Speed specification defines a maximum theoretical data transfer rate of:
(A) 12 Mbps
(B) 480 Mbps
(C) 5 Gbps
(D) 10 Gbps

2024
263. The context of a task in an RTOS minimally includes:
(A) The global and static variable allocations in the system heap
(B) The compiler configurations and link-time address maps
(C) The process ID and file descriptor tables in user space
(D) The CPU general-purpose registers, Program Counter, and Stack Pointer

2005
264. What is a primary symptom of "Stack Overflow" in an embedded system?
(A) Stack pointers grow beyond bounds, corrupting adjacent memory space
(B) The processor clock frequency is automatically throttled
(C) The non-volatile program memory is permanently erased
(D) Dynamic memory allocation returns null pointers immediately

2013
265. Priority Inheritance Protocol prevents priority inversion by:
(A) Forcing all executing system tasks to run at the highest possible priority
(B) Temporarily elevating the priority of the lower-priority resource-holding task to match that of the higher-priority waiting task
(C) Terminating the lower-priority task if it holds the resource for too long
(D) Disabling interrupts during the entire duration of resource access

NODIA

2014
266. A cross-compiler hosted on an x86 Windows PC targeting an ARM Cortex-M microcontroller outputs:
(A) Standard x86 machine code executed on the host PC
(B) Target ARM machine code executable on the device
(C) Standard Windows API executable binaries on host
(D) Assembly code optimized for x86 processors

2024
267. In HW/SW Co-Design, what is the primary role of an ASIC in an otherwise software-heavy system?
(A) To accelerate computationally heavy, time-critical software tasks
(B) To execute the core software kernel of standard operating systems
(C) To serve as slow auxiliary storage for persistent backup memories
(D) To provide physical power regulation to electronic system boards

2015
268. Which debugging method minimally intrudes on the real-time execution of the embedded system?
(A) Inserting hundreds of active debug printf statements inside source code
(B) Halting target processor execution using software breakpoint routines
(C) Streaming real-time execution metrics using hardware trace modules
(D) Controlling on-board LED indicator pins using software busy delays

2022
269. The utilization of "Soft IP cores" in an FPGA design flow offers the distinct advantage of:
(A) Allowing intellectual cores to be physically adjusted by systems engineers
(B) Guaranteeing physical timing metrics prior to logic synthesis operations
(C) Requiring zero hardware logic synthesis or software compilation tool runs
(D) High portability across different FPGA families or standard-cell ASIC processes

Discovery)
Which of the following represents the correct sequence?
(A) III, I, IV, II
(B) I, III, IV, II
(C) III, IV, I, II
(D) I, IV, III, II

2023
231. The term "Baud Rate" in serial communication defines:
(A) The absolute count of physical binary data bits sent every second
(B) The peak electrical voltage level representing logical high state
(C) The total storage footprint size of receiver memory buffer systems
(D) The total count of physical signal state changes made each second

2005
232. Which of the following is true regarding RS-485 compared to RS-232?
(A) RS-485 supports multi-drop networks using up to 32 transceivers
(B) RS-485 is restricted to significantly shorter wire loop distances
(C) RS-485 uses single-ended signaling paths instead of differential
(D) RS-485 is limited to transmission rates below 9600 bps

2025
233. In USB architecture, the host controller communicates with devices using a structured format. What is the basic unit of this communication?
(A) An analog carrier wave
(B) A digital packet
(C) A continuous file stream
(D) A high-level software command

2019
234. Ethernet relies on CSMA/CD. What does the "CD" stand for?
(A) Carrier Detection scheme
(B) Collision Detection
(C) Constant Data Flow rates
(D) Computer Delivery system

2002
235. The IEEE 802.11 (Wi-Fi) standard operates in which frequency bands?
(A) 2.4 GHz and 5.0 GHz ISM bands
(B) Medium wave AM radio spectrum
(C) Infrared light wave frequency
(D) X-ray physical spectrum bands

2018
236. A task in an RTOS transitions from the "Ready" state to the "Running" state when:
(A) It initiates an active input or output peripheral device operation
(B) It encounters an unexpected division by zero logic execution error
(C) The system scheduler selects it based on priority and availability
(D) It enters an inactive low-power processor sleep state environment

2001
237. What defines a "reentrant" function in embedded software?
(A) A function that must execute to completion without any hardware interrupts
(B) A function that automatically re-executes whenever an error occurs
(C) A function that disables task switching while it is executing
(D) A function that can be safely called by multiple concurrent threads or tasks without data corruption

2021
238. To ensure a function is reentrant, a developer should avoid using:
(A) Local variables that are allocated directly on task processor stacks
(B) Standard mathematical operators like addition or logic multiplication
(C) Global or static variables not protected by mutual exclusion methods
(D) Standard function argument inputs passed directly by value parameter

2019
239. What is a watchdog timer (WDT)?
(A) A software algorithm designed to monitor network traffic for cyber attacks
(B) A hardware timer resetting the CPU when software fails to clear it in time
(C) An RTOS background routine printing the active system time to the console
(D) A physical system device synchronizing independent node clocks on networks

2019
240. Which IPC method involves passing a pointer to an RTOS object to notify a task of an event?
(A) Message Queue
(B) Binary Semaphore
(C) Priority Ceiling

Click Here to Buy book on Flipkart

2014
202. What is the primary role of a linker script (or scatter file) in the embedded toolchain?
(A) To translate high-level C source code into clean Python scripts
(B) To define the target board memory layout and place code sections
(C) To compress raw source code files to save physical storage space
(D) To simulate complex hardware device behavior on a host computer

2010
203. The ".bss" section of an executable image typically contains:
(A) Uninitialized global and static variables zeroed at system boot
(B) Executable machine instruction binaries stored in active memory
(C) Pre-initialized global and static variables with default values
(D) Dedicated memory partitions reserved for RTOS task stack space

2017
204. In the context of hardware synthesis, what does RTL stand for?
(A) Resistor-Transistor Logic
(B) Real-Time Layer
(C) Register-Transfer Level
(D) Routing and Timing Layout

2009
205. Which synthesis step transforms a generic logic gate representation into a technology-specific netlist (e.g., specific to a TSMC 65nm process)?
(A) High-level synthesis
(B) RTL synthesis
(C) Behavioral simulation
(D) Technology mapping

2022
206. High-Level Synthesis (HLS) tools typically take which of the following as input?
(A) Physical layout binary files in GDSII
(B) Low-level processor assembly language
(C) C/C++ or SystemC algorithmic source
(D) Detailed analog transistor netlists

2003
207. During HW/SW co-design, "profiling" tools help determine:
(A) The physical parasitic parameters of routed board traces
(B) The execution times and resource utilization of software functions to identify bottlenecks
(C) The physical parasitics of the routed interconnect lines
(D) The manufacturing yields of the silicon wafer

2011
208. The main objective of Hardware/Software Co-simulation is to:
(A) Avoid writing any software programs until products are sold
(B) Generate high-accuracy heat maps for thermal cooling units
(C) Automatically translate software into physical hardware molds
(D) Validate software and hardware model interaction concurrently

2007
209. Which verification methodology utilizes automated mathematical algorithms to guarantee that a design does not violate specified properties?
(A) Formal Verification
(B) Logic Analyzer Probing
(C) JTAG Debugging
(D) Oscilloscope Measurement

NODIA

2017
210. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Hardware emulation is significantly faster than purely software-based RTL simulation.
Reason (R): Emulation maps the RTL design onto physical reconfigurable hardware arrays (like FPGAs) to execute the logic concurrently.
In the light of the above statements, choose the correct answer from the options given below:
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2009
211. What is an Instruction Set Simulator (ISS)?
(A) A software model running on a host machine that mimics the execution behavior of a target processor instruction set
(B) A hardware-based emulator that synthesizes custom digital logic
(C) A mechanical device used to test the thermal tolerance of CPU chips
(D) A compiler tool used to generate assembly

III. Logic Synthesis
IV. Place and Route
Which of the following represents the correct sequence?
(A) I, II, III, IV
(B) II, I, IV, III
(C) I, III, II, IV
(D) III, I, IV, II

2006
251. An intellectual property (IP) core that is delivered as routed and physically mapped GDSII layout is called:
(A) Hard IP
(B) Soft IP
(C) Firm IP
(D) Behavioral IP

2005
252. The AMBA (Advanced Microcontroller Bus Architecture) standard, heavily used for SoC interconnects, was introduced by:
(A) Intel
(B) Microsoft
(C) ARM
(D) IBM

2012
253. Which technology provides the most cost-effective solution for a high-volume product (e.g., millions of units) requiring extremely low power and small area?
(A) Off-the-shelf General-Purpose Processor
(B) Field Programmable Gate Array (FPGA)
(C) Complex Programmable Logic Device (CPLD)
(D) Full-Custom ASIC

2002
254. In RT-Linux, what happens when a standard Linux process requests the CPU while a real-time task is executing?
(A) The standard Linux process immediately preempts the real-time task
(B) The system kernel immediately triggers an unrecoverable kernel panic
(C) The real-time task continues executing, deferring standard Linux run
(D) Both tasks execute concurrently on a single core using rapid slicing

2024
255. Which IPC mechanism inherently behaves as a FIFO (First-In, First-Out) buffer for byte streams?
(A) Binary Semaphore
(B) Pipe
(C) Event Register
(D) Priority Ceiling

2014
256. What defines the "Jitter" of a periodic task in a real-time system?
(A) The physical vibration or shaking of the embedded hardware casing
(B) The maximum physical capacity of RAM memory utilized by the task
(C) The total execution time needed to run the task once
(D) The statistical timing variance in task start or completion times

2019
257. Which standard defines the physical layer and media access control for a wireless personal area network (WPAN) used by Bluetooth?
(A) IEEE 802.3
(B) IEEE 802.11
(C) IEEE 802.15.1
(D) IEEE 1394

2024
258. In an FPGA, the programmable interconnects are responsible for:
(A) Executing compiled software program instructions inside the ALU blocks
(B) Supplying stable electrical power lines to all peripheral components
(C) Providing physical electrical routing pathways to connect logic blocks
(D) Storing the configuration bitstream permanently

NODIA

2012
259. A primary benefit of using a microprogrammed control unit over a hardwired control unit is:
(A) It simplifies instruction set updates by altering microcode control store
(B) It delivers faster instruction execution speed
(C) It reduces the overall dynamic power consumption of the processor
(D) It eliminates the need for any sequential state registers in the control logic

2014
260. A digital signal processor (DSP) features a "Zero-Overhead Loop" capability. This means:
(A) Loops are processed without drawing any dynamic electrical currents
(B) Loop instructions are executed in parallel on multiple ALUs
(C) Loops require zero memory storage footprints

ANSWERS

1. (D) A computing system designed for specific control functions with strict deterministic timing constraints
A real-time embedded system is designed specifically to perform dedicated control functions under strict, deterministic timing constraints. Unlike general-purpose computers, these systems must guarantee that critical tasks execute within predictable time frames. Failing to meet these operational deadlines can lead to system malfunction or total failure, making precise timing a fundamental design requirement.

2. (C) Missing a deadline in a hard real-time system leads to total system failure
Hard real-time systems differ from soft real-time systems based on the severity of missing a deadline. In hard real-time environments, failing to meet a timing constraint is catastrophic and results in total system failure. Conversely, soft real-time systems can tolerate occasional deadline misses, which only degrade system performance or quality of service without causing critical damage.

3. (B) Stringent power consumption limits
Portable embedded devices operate on limited battery sources, making power dissipation a critical design constraint. Engineers must optimize hardware and software to minimize active and leakage power, extending battery life without sacrificing performance. This requirement influences decisions regarding processor selection, clock frequency scaling, low-power sleep modes, and memory architectures during the design process.

4. (D) They are exclusively implemented using full-custom VLSI circuits
Embedded systems are highly versatile and implemented using various technologies like microcontrollers, digital signal processors, field-programmable gate arrays, and semi-custom integrated circuits. Implementing them exclusively with full-custom integrated circuits is impractical due to extreme development costs and long time-to-market. Most applications leverage pre-designed components to balance cost, flexibility, and production volume constraints.

5. (A) The ability to guarantee a specific response within a predictable timeframe
Determinism in real-time computing refers to the system ability to produce identical and predictable timing results for given inputs. This predictability guarantees that task execution, interrupt handling, and resource scheduling occur within strictly defined, consistent intervals. Unlike general-purpose systems prioritizing throughput, real-time architectures prioritize this reliable temporal predictability to avoid catastrophic system control failures.

6. (C) Energy efficiency and leakage power
For battery-operated medical implants, maximizing battery longevity is paramount to avoid frequent invasive replacement surgeries. Consequently, energy efficiency and minimizing static leakage power represent the most critical design metrics. The hardware must remain in ultra-low-power sleep states for extended periods, and wakeup cycles must consume minimal energy while maintaining reliable operation.

7. (A) Balancing the trade-off between execution speed and power consumption
A central challenge in co-design optimization involves managing the trade-off between execution performance and power dissipation. Enhancing speed often requires higher clock frequencies or dedicated hardware, which increases energy consumption. System designers must carefully partition tasks between custom hardware circuits and flexible software microprocessors to achieve the desired throughput while staying within strict power budgets.

8. (D) It promotes using pre-designed IP cores and standard COTS components
Strict time-to-market constraints force developers to accelerate the product design cycle. To achieve this, engineers frequently avoid designing circuits from scratch, choosing instead pre-designed intellectual property cores and standard commercial off-the-shelf components. This methodology significantly reduces

Downloaded from www.pdf.tube

2001

270. System verification differs from system validation in that:

(A) Verification is performed only on software, while validation runs on hardware

(B) Validation processes occur prior to writing software in standard design flows

(C) Verification checks specification matching, while validation tests user needs

(D) Verification evaluates the physical board layout dimensions and packaging tolerances

****

NODIA

(D) Mailbox

2017

241. What is the fundamental cause of the "Deadlock" anomaly?
(A) Multiple tasks waiting for resources held by each other in a circle
(B) A single processor task executing continuously without yielding CPU
(C) The operating system running out of dynamic heap space
(D) Hardware interrupts firing at extremely rapid rates in the system

2001

242. In a hard real-time system, the Worst-Case Execution Time (WCET) of tasks must be known primarily to:
(A) Optimize overall battery life and minimize thermal dissipation
(B) Reduce the actual physical capacity size of the Flash memory
(C) Prove via scheduling analysis that task deadlines will be met under worst-case workloads
(D) Select the correct compiler optimization flag settings for run

2006

243. Which of the following is considered an Advanced IPC mechanism designed specifically for handling complex, multi-condition synchronization (e.g., Task A waits for Event 1 AND Event 2)?
(A) Event Flag and Event Register structures
(B) Simple Mutual Exclusion Mutex operations
(C) Active Spinlock Loop Barrier structures
(D) Global Boolean Status Variable pointers

2009

244. When comparing Embedded Linux to a dedicated RTOS like µC-OS, Embedded Linux generally has:
(A) A much smaller physical footprint of kernel RAM and ROM memory
(B) Stricter hard real-time execution determinism directly on chip
(C) No support for standard multi-threading
(D) Extensive networking, file system, and GUI software interfaces

2003

245. A bootloader in an embedded system is responsible for:
(A) Managing active system tasks and semaphores during normal system execution
(B) Initializing hardware systems and loading applications into active memory
(C) Translating high-level source code directly into targeted machine binaries
(D) Designing and rendering graphical user interface views on physical displays

2003

246. What is the primary purpose of the Task Control Block (TCB) in an RTOS?
(A) To store the binary machine code of the task's instructions
(B) To maintain the execution state, priority, and context of a task
(C) To manage the hardware interface of the physical timer interrupt
(D) To allocate global dynamic memory pools for the system kernel

2017

247. The primary challenge in system synthesis (HW/SW Co-Design) is determining:
(A) The exact physical layout location of the system battery on a board
(B) Which software programming language features the best visual syntax
(C) The color coding standards of internal physical electrical wirings
(D) The optimal partitioning of tasks to meet performance constraints

2002

248. Logic Synthesis translates a High-Level Description (like Verilog) directly into:
(A) A gate-level netlist of interconnected logic gates
(B) Optimized executable software C++ logic source files
(C) Functional front-end graphical user interface views
(D) Mechanical system housing and outer casing elements

2001

249. Which form of verification actively proves the absence of specific bugs across all possible states without running simulated test cases?
(A) In-circuit Emulation
(B) Formal Verification
(C) Random Testbench Simulation
(D) JTAG Boundary Scan

2004

250. Arrange the following steps of the typical Hardware Design Flow:
I. System Specification
II. Behavioral Simulation

Click Here to Buy book on Amazon

development time, simplifies system verification, minimizes non-recurring engineering costs, and allows designers to focus on core software applications.

9. (B) The one-time cost of researching, designing, and testing a new product
Non-recurring engineering costs represent the one-time expenditures incurred during the research, design, schematic capture, physical layout, simulation, and prototyping phases of a product. Unlike recurring manufacturing costs, which apply to every unit fabricated, this initial development cost is fixed. It must be amortized over the total volume of units sold to determine product profitability.

10. (A) Both A and R are true and R is the correct explanation of A.
General-purpose processors offer a highly cost-effective solution for low-volume embedded applications due to minimal non-recurring engineering costs. Because semiconductor vendors mass-produce these chips for a broad market, the massive initial mask and fabrication development costs are distributed among thousands of customers. Designers merely write software, avoiding the high custom silicon design expenses.

11. (D) Single-purpose custom processor
A single-purpose custom processor is designed specifically to execute a single algorithm, utilizing dedicated hardware paths such as optimized pipelines, parallel computational units, and application-specific registers. This specialized physical architecture eliminates instruction fetching, decoding overhead, and general-purpose resource conflicts. Consequently, it achieves superior execution speed, optimal silicon area efficiency, and minimal power consumption for its designated task.

12. (A) Its instruction set is tailored to a specific application domain
An application-specific instruction-set processor represents a hybrid architecture featuring a programmable core with a customized instruction set tailored for a particular application domain. This configuration provides a balanced solution, delivering near-hardware performance for specialized mathematical operations while maintaining the flexibility of software programmability. This versatility allows developers to update algorithms without redesigning the underlying hardware chip.

13. (B) It allows rapid development with widely available software tools
Using general-purpose processors in embedded systems significantly accelerates development due to the extensive ecosystem of mature compilers, software libraries, debuggers, and operating systems. Developers can write code in high-level languages, which simplifies debugging and reduces software complexity. This widespread tool availability lowers engineering barriers, shortens time-to-market, and simplifies long-term firmware maintenance and system upgrades.

14. (B) Execution speed and power efficiency
Replacing dedicated physical logic with a programmable general-purpose processor introduces significant instructional overhead, including continuous instruction fetching, decoding, and general register management. For highly repetitive mathematical operations, this software-based execution pathway drastically reduces speed and increases power dissipation. Custom architectures bypass this overhead entirely through dedicated parallel hardware pipelines, maximizing throughput and energy efficiency.

15. (A) Application-Specific Integrated Circuit
An application-specific integrated circuit is a customized silicon chip designed for a particular application or product rather than general-purpose use. This technology delivers outstanding electrical performance, minimal physical size, and optimized power efficiency. However, developing these custom chips requires high non-recurring engineering costs and extended design periods, making them suitable primarily for high-volume production.

16. (C) Full-custom VLSI has very high NRE costs and development times
Full-custom very large scale integration design requires manually laying out every transistor and routing physical interconnects on the silicon. This meticulous engineering process leads to extremely high non-recurring engineering costs and exceptionally long development cycles. Programmable logic devices, conversely, are pre-fabricated chips configured using software,

NODIA

72. (D) A function triggered to handle an asynchronous event immediately
An interrupt service routine is a specialized callback function designed to handle asynchronous hardware events immediately. When an external peripheral triggers an interrupt, the processor pauses current execution, saves its state, and runs the corresponding ISR to service the event. These routines must remain compact and execute quickly to minimize system interrupt latency.

73. (B) The delay from interrupt request to the start of the ISR
Interrupt latency is defined as the total time delay between the generation of an hardware interrupt request and the execution of the first instruction within the corresponding interrupt service routine. This interval includes hardware synchronization delays, processor context-saving overhead, and the time required to locate the correct interrupt vector address.

74. (C) A higher-priority interrupt preempting a lower-priority ISR
Interrupt nesting occurs when a higher-priority hardware interrupt preempts an active interrupt service routine of lower priority. Instead of waiting for the current routine to complete, the processor pauses it, saves its state, and immediately executes the new, urgent service routine. This hierarchical handling ensures that critical real-time events receive immediate processor attention.

75. (D) Keep ISRs extremely short and defer heavy processing to tasks
To minimize interrupt latency in hard real-time systems, designers must keep interrupt service routines extremely short. ISRs should only perform essential hardware interactions, such as clearing flags or reading registers, and immediately defer intensive data processing to background software tasks. This strategy minimizes the time global interrupts are disabled, ensuring highly responsive system performance.

76. (A) A memory address pointing to the start location of the target ISR
An interrupt vector is a dedicated memory address that contains the starting location of a specific interrupt service routine. When a peripheral triggers an interrupt, the processor references its interrupt vector table using the interrupt number to locate and jump to the correct instruction sequence, enabling swift and organized hardware event handling.

77. (B) Mutually exclusive access to a single resource
A binary semaphore is a synchronization primitive that takes only two values, zero and one, to manage mutual exclusion. It is primarily used to control access to a single shared resource, such as a peripheral interface or memory buffer, preventing data corruption by ensuring only one task accesses the protected resource at any given time.

78. (B) It can take any non-negative integer to manage multiple resources
A counting semaphore differs from a binary semaphore by utilizing an internal counter that can take any non-negative integer value. This capability allows it to manage access to a pool of identical shared resources. The semaphore value decrements as tasks acquire resources and increments as they are released, blocking tasks when the pool is empty.

79. (A) Mutex (Mutual Exclusion object)
A mutual exclusion object, or mutex, is a specialized synchronization primitive designed to protect shared resources. Unlike a basic binary semaphore, a mutex is owned by the task that locks it and inherently implements priority inheritance protocols. This mechanism dynamically elevates the priority of the resource holder, effectively preventing dangerous unbounded priority inversion anomalies.

80. (A) I and II
Mutexes feature strict ownership rules, meaning only the specific task that acquired the lock can release it, preventing unauthorized resource manipulation. Conversely, binary semaphores lack ownership constraints, allowing interrupt service routines to signal them. In single-core processors, spinlocks waste processing cycles and are generally avoided in favor of blocking synchronization primitives during long waits.

81. (D) Deadlock
A deadlock is a critical synchronization failure that occurs when two or more tasks are blocked indefinitely, each waiting for a shared resource held by the other. This circular dependency prevents any of the involved tasks from making progress. Resolving or preventing deadlocks requires careful resource allocation strategies,

Downloaded from www.pdf.tube

its algorithmic procedures in a correct, orderly chronological sequence.

26. (C) Execution units like ALUs, multipliers, and registers
The datapath of a custom single-purpose processor contains the physical hardware structures dedicated to manipulating and storing data. It consists of arithmetic execution units like arithmetic logic units, multipliers, and shifters, along with registers for temporary storage and multiplexers to route data signals. It acts under the guidance of control signals generated by the control unit.

27. (D) To generate signals that direct data flow through the datapath
The control unit acts as the coordinator of a custom processor. It interprets instructions or current machine states to generate coordinated control signals. These signals determine when registers capture data, which mathematical operations the arithmetic logic unit performs, and how data routes through multiplexers, thereby guiding the step-by-step movement of data within the system datapath.

28. (A) Algorithmic State Machine with Datapath (ASMD)
The algorithmic state machine with datapath model is a structured design methodology used to design complex control units. It integrates state transition pathways with specific datapath actions, allowing engineers to visualize hardware control sequences and data operations simultaneously. This approach ensures precise synchronization between the control logic and the physical execution units during digital design.

29. (B) Utilizing spatial parallelism or hardware multipliers in the datapath
To accelerate repetitive arithmetic tasks in a custom processor, designers can implement spatial parallelism or dedicated hardware multipliers. By replicating physical computation units, the system can perform multiple mathematical operations simultaneously within a single clock cycle. This hardware acceleration eliminates the bottleneck of sequential loop iterations, significantly enhancing execution throughput at the expense of additional silicon area.

30. (C) I and III
Modern digital processors are logically separated into two distinct blocks: the datapath, which manipulates raw data, and the control unit, which governs step-by-step operations. Separating these elements simplifies functional verification and design modification. Additionally, control units can be constructed using dedicated hardwired state machine logic for speed, or flexible microprogrammed architectures for easier modification.

31. (A) Clock gating to disable inactive functional blocks
Clock gating is a highly effective design technique for reducing dynamic power consumption in CMOS digital circuits. It works by disabling the clock signal to registers and functional units that are idle during specific execution states. This prevents unnecessary physical transistor switching, which represents the primary source of dynamic power dissipation in active integrated semiconductor devices.

NODIA

32. (C) It increases hardware area but enables parallel execution
Loop unrolling is an optimization technique that replicates loop execution bodies to execute multiple iterations in parallel. In hardware design, this replication increases the required silicon area because more physical execution units, registers, and interconnects must be synthesized. However, it significantly increases processing speeds by reducing loop overhead and enabling high levels of concurrent spatial computation.

33. (D) It enables a higher clock frequency by reducing critical path delay
Pipelining enhances processor performance by dividing complex sequential processing steps into shorter, independent pipeline stages separated by registers. This structural division reduces the critical path propagation delay of the longest combinational logic segment. Consequently, the processor can operate at a significantly higher clock frequency, increasing the throughput of completed instructions over time.

34. (C) Sharing functional units like ALUs across different machine states
To minimize the physical silicon footprint of an integrated circuit, designers focus on sharing hardware resources. By multiplexing a single functional execution unit, such as an arithmetic

53. (D) IEEE 1394
The Firewire interface, developed by Apple and standardized under the IEEE 1394 specification, is a high-speed serial bus designed for real-time data transfers. It supports peer-to-peer communication, allowing compatible devices to exchange data directly without requiring a central computer host, making it highly useful for connecting digital cameras and multimedia storage systems.

54. (C) It uses CSMA/CD mechanisms in half-duplex operating modes
The IEEE 802.3 Ethernet standard defines local area network communications. In half-duplex environments, it utilizes carrier sense multiple access with collision detection protocols to manage shared medium access. Devices listen to the transmission line before transmitting, detect signal collisions if multiple nodes transmit simultaneously, and back off for random intervals before reattempting data delivery.

55. (A) Direct peer-to-peer transfers without a host controller
A key distinction of the IEEE 1394 Firewire standard is its inherent support for peer-to-peer network communication. Unlike the host-centric USB architecture, which requires a master computer host to manage all data transfers, Firewire devices can negotiate bus access and transmit data directly to one another, simplifying decentralized peripheral interconnect systems.

56. (D) USB Isochronous Transfer
USB isochronous transfers are specifically designed for streaming time-sensitive payloads like audio or real-time video. This transfer mode guarantees a constant, reserved bus bandwidth and deterministic delivery latency, prioritizing timing over absolute accuracy. Error correction and retransmissions are omitted, meaning occasional dropped packets are tolerated to maintain a continuous, real-time data stream.

57. (B) IrDA (Infrared Data Association) technology
The Infrared Data Association standard relies on infrared light-emitting diodes to transmit digital data using light wavelengths outside the visible spectrum. This wireless technology requires a clear line of sight and close physical alignment between the transmitting and receiving devices. It provides a secure, short-range, point-to-point communication channel resilient to radio frequency interference.

58. (C) Physical and Data Link OSI layers
The IEEE 802.11 Wi-Fi standard defines the physical and data link layers of the open systems interconnection model. The physical layer specifies radio frequency bands, modulation schemes, and signal transmission parameters. The data link layer, divided into logical link control and medium access control sublayers, governs wireless channel access, framing structures, and error detection mechanisms.

59. (D) Bluetooth wireless standard
The Bluetooth wireless standard utilizes frequency-hopping spread spectrum techniques to reduce signal interference in the crowded 2.4 gigahertz band. By rapidly switching radio transmission frequencies up to sixteen hundred times per second across multiple channels, Bluetooth maintains reliable communication even in environments with active Wi-Fi routers, microwaves, and other wireless devices.

60. (A) Both A and R are true and R is the correct explanation of A.
Infrared Data Association technology provides excellent physical security against remote eavesdropping. Because it relies on line-of-sight propagation with a narrow infrared beam, communication is restricted to close physical proximity. Signals do not penetrate physical walls, unlike omnidirectional radio frequency protocols like Wi-Fi, preventing intercept by unauthorized devices situated outside the room.

61. (B) 7
A Bluetooth piconet is an ad-hoc network consisting of one primary master device and multiple secondary slave units. The architecture allows a maximum of seven active slave devices to communicate simultaneously with the master within a single piconet. Additional slave devices can remain connected to the network in a low-power, inactive parked state.

62. (B) The Kernel Scheduler
The kernel scheduler is the core component of a real-time operating system responsible for allocating central processing unit execution time. Using defined scheduling algorithms, it determines which active task enters the running state. In an RTOS, this selection process

Click Here to Buy book on Flipkart

a single silicon chip. This complete integration reduces overall component count, simplifies printed circuit board design, minimizes power dissipation, and lowers manufacturing costs compared to systems using discrete microprocessors.

44. (A) Direct Memory Access (DMA)
Direct memory access controllers are vital in digital signal processing to sustain high-speed data streams. This hardware subsystem allows peripheral devices to transfer data blocks directly to and from system memory without continuous central processing unit intervention. Bypassing the processor during input-output operations preserves CPU cycles for executing complex mathematical filtering and signal analysis algorithms.

45. (B) Modified Harvard architecture
Digital signal processors commonly employ a modified Harvard architecture to maximize data throughput during intensive calculations. This memory configuration provides separate physical buses for instruction memory and data memory, allowing the processor to fetch an instruction and access data variables simultaneously. This parallel access avoids the memory bottlenecks inherent in traditional single-bus Von Neumann designs.

46. (B) Pre-agreed baud rates and framing bits
The universal asynchronous receiver-transmitter protocol operates without a shared physical clock signal. Instead, it relies on pre-configured, matching transmission baud rates at both ends, combined with specific framing bits. Start and stop bits are added to each transmitted data byte, allowing the receiving hardware to detect incoming data and synchronize its internal sampling clock.

47. (A) A single-ended standard for asynchronous serial transmission
The RS-232 standard defines a single-ended physical layer protocol used for asynchronous serial communication. It specifies the electrical signal voltages, timing characteristics, and physical pin configurations for point-to-point data transmission over short distances. Because it relies on single-ended signaling referenced to a common ground, it remains susceptible to electrical noise over long cable runs.

48. (C) They use differential signaling, offering better noise immunity
The primary benefit of the RS-422 and RS-485 standards is their use of differential signaling. By transmitting signals as voltage differences across twisted wire pairs, these standards effectively cancel out common-mode electromagnetic noise. This design delivers superior noise immunity, enabling reliable serial communication over much longer distances and in harsh industrial environments.

49. (D) RS-485
The RS-485 physical layer standard is designed to support multi-point topologies, allowing multiple transmitters and receivers to share a single differential bus line. This half-duplex configuration uses high-impedance receiver states and tri-state drivers to avoid signal conflicts, making it highly effective for connecting multiple nodes in industrial automation and control networks.

50. (A) I, II and IV
Asynchronous serial protocols like UART transmit data without sharing a physical clock line, relying instead on start and stop framing bits. Additionally, RS-232 interfaces employ positive and negative bipolar voltage levels, rather than simple logic levels. Simple parity bits provide basic single-bit error detection but lack the capability to perform complex multi-bit error corrections.

51. (B) Tiered star topology
The universal serial bus protocol utilizes a tiered star topology to connect multiple peripheral devices to a host controller. At the center of each star is a USB hub, which routes data down to individual devices or additional nested hubs. This organized tree-like layout provides structured power distribution and point-to-point data routing across all connected nodes.

52. (D) It is a part of a USB device that acts as a source or sink of data
In the USB communication protocol, an endpoint represents a uniquely addressable buffer on a peripheral device that serves as a source or sink of data. The host controller establishes logical pipes to these endpoints to transfer information. Each endpoint supports specific transfer types, such as control, bulk, interrupt, or isochronous data transactions.

Downloaded from www.pdf.tube

91. (D) Priority Inversion
The Mars Pathfinder spacecraft experienced frequent system resets due to an unhandled priority inversion anomaly in its real-time operating system. A low-priority meteorological task held a shared information bus lock, while medium-priority communication tasks preempted it. This blocked a high-priority attitude control task indefinitely, triggering a watchdog timer reset that interrupted exploration operations.

92. (A) A hardware timer driving a software tick counter within the RTOS
An embedded software timer is fundamentally implemented using a physical hardware timer configured to generate periodic interrupts. These interrupts drive a software tick counter within the real-time operating system kernel. The kernel references this system tick to track elapsed time, decrement software timer counters, and transition blocked tasks back to the ready state.

93. (B) It causes fragmentation and non-deterministic execution times
Dynamic memory allocation is avoided in hard real-time systems because standard heap managers exhibit non-deterministic execution times. Searching for free memory blocks depends on the state of the heap, making allocation times unpredictable. Additionally, continuous allocation and deallocation cause memory fragmentation, which can lead to runtime out-of-memory failures in critical embedded applications.

94. (B) Fixed-size memory block partitions (Memory Pools)
To bypass the non-deterministic timing and fragmentation issues of traditional heap allocation, real-time operating systems utilize memory pools. These pools consist of pre-allocated partitions of fixed-size memory blocks. Tasks can allocate and release these blocks in constant time, ensuring deterministic execution speed and eliminating physical memory fragmentation in critical embedded applications.

95. (A) Placing the CPU in a low-power sleep mode until the next interrupt
When no application tasks are ready to run, the real-time operating system scheduler executes a low-priority background idle task. To conserve power, this idle task typically invokes a processor instruction that places the CPU into a low-power sleep state. The processor remains in this energy-saving state until a hardware interrupt wakes it up.

96. (C) Dynamically adjusting frequency and voltage based on execution workloads
Dynamic voltage and frequency scaling is an effective power management technique used in modern embedded processors. It dynamically reduces the core clock frequency and operating voltage during periods of low computational workload. Because dynamic power consumption scales quadratically with voltage, this reduction yields substantial energy savings while maintaining sufficient performance to meet active task deadlines.

97. (D) A portable, ROMable, preemptive real-time multitasking kernel
The µC-OS kernel is a highly portable, ROMable, preemptive real-time multitasking kernel designed specifically for embedded systems. It features a compact memory footprint and highly deterministic execution times, making it suitable for resource-constrained microcontrollers. Its clean code structure allows easy adaptation across various processor architectures, providing robust priority-based task scheduling.

NODIA

98. (C) Running standard Linux as a low-priority task under a real-time kernel
RT-Linux achieves hard real-time performance by inserting a lightweight real-time kernel beneath the standard Linux operating system. In this architecture, the standard Linux kernel runs as the lowest-priority idle task under the real-time scheduler. The real-time kernel intercepts hardware interrupts, ensuring time-critical tasks execute immediately with predictable, microsecond-level latency.

99. (B) It is open-source, highly customizable, and supports multiple architectures
Embedded Linux is characterized by its open-source nature, high customizability, and extensive support for diverse processor architectures. Developers can strip down the kernel to fit specific hardware constraints, integrating required drivers and network protocols. This flexibility, combined with a vast community ecosystem and zero licensing royalties, makes it highly popular for complex connected embedded systems.

prioritizes deterministic execution behavior, ensuring critical tasks meet their deadlines over general system throughput.

63. (A) Blocked state
In a real-time operating system, a task enters the blocked state when it cannot continue execution because it is waiting for an external event or resource. This includes waiting for hardware interrupts, message queue signals, or semaphores. The scheduler ignores blocked tasks, preserving valuable CPU execution cycles for other active tasks in the ready state.

64. (C) Active task state is saved, and the next ready task state is loaded
During an RTOS context switch, the kernel scheduler pauses the currently running task to allocate CPU cycles to a higher-priority task. The scheduler saves the execution state of the active task, including its program counter and processor registers, to its task control block, then restores the saved state of the next ready task from its control block.

65. (D) Saving and restoring CPU registers to and from the task control block
Context switch latency represents the time overhead required to switch processor execution from one task to another. This latency is primarily driven by the physical memory operations needed to save active CPU register values into the old task control block, followed by loading the saved register state of the new task from its control block.

66. (C) The compiled binary instructions of the task
A task control block is a dedicated kernel data structure that stores management metadata for an active task, such as its priority, run state, and stack pointer. It does not contain the compiled binary instructions of the task, which reside separately in non-volatile program memory or system code space accessed via the program counter.

67. (B) Non-preemptive (Cooperative) Scheduling
Non-preemptive, or cooperative, scheduling executes the active task continuously until it either completes its operation or voluntarily relinquishes control of the processor. Even if a higher-priority task becomes ready, the running task cannot be forcefully interrupted. This simplifies system design by avoiding complex task synchronization issues but increases scheduling latency for urgent events.

68. (D) Tasks with shorter periods receive higher priorities
Rate monotonic scheduling is a static-priority scheduling algorithm designed for periodic real-time tasks. It assigns execution priorities based on the recurrence period of each task. Tasks with shorter execution periods receive higher priority rankings, while those with longer periods are assigned lower priorities. This static allocation method guarantees determinism in predictable real-time systems.

69. (A) Dynamic priority scheduling
Earliest deadline first is a dynamic scheduling algorithm that assigns task execution priorities at runtime based on proximity to absolute deadlines. The task with the closest deadline is automatically assigned the highest execution priority. This dynamic prioritization allows EDF to achieve up to one hundred percent processor utilization while guaranteeing that all scheduled real-time tasks meet deadlines.

70. (B) P-2, Q-1, R-4, S-3
Different real-time scheduling algorithms provide unique prioritization schemes. Rate monotonic scheduling assigns fixed static priorities based on task execution periods. Earliest deadline first dynamically calculates priority based on impending deadlines. Round-robin scheduling provides equal execution time slices to ready tasks sequentially, while first-come first-served executes tasks non-preemptively based on their arrival times.

71. (A) It must guarantee that all task deadlines are met
The core requirement of a hard real-time scheduling mechanism is guaranteeing that all critical task deadlines are met under all operating conditions. The scheduling algorithm must be deterministic, ensuring predictable execution behavior. Failing to meet a single deadline in these environments constitutes a catastrophic failure, meaning average-case performance metrics are secondary to worst-case execution bounds.

Click Here to Buy book on Amazon

logic unit, across different machine states, the need for redundant hardware is eliminated. This spatial sharing reduces total logic gate counts, leading to a highly compact and cost-effective chip layout.

35. (B) It quadratically decreases dynamic power but increases propagation delay
Reducing the supply voltage in a CMOS integrated circuit results in a quadratic decrease in dynamic power dissipation, since dynamic power is proportional to the square of the voltage. However, this lower operating voltage decreases transistor drive currents, which increases propagation delay. This trade-off requires designers to balance power-saving goals with system speed performance constraints.

36. (D) Program Counter (PC)
The program counter is a dedicated hardware register within a central processing unit that holds the memory address of the next instruction scheduled for execution. As each instruction is fetched from memory, the program counter automatically increments to point to the next instruction, or updates to a different address when branching or jump instructions occur.

37. (A) The opcode is analyzed and register operands are fetched
During the instruction decode stage of a processor pipeline, the control logic analyzes the fetched binary instruction to identify the operation code. Simultaneously, the execution unit accesses the register file to fetch the required source operand values. This critical stage prepares the processor control signals and data inputs before active computation begins in the execution stage.

38. (C) A delay because an instruction depends on a previous unfinished result
A data hazard occurs in pipelined processors when an instruction scheduled for execution relies on data produced by a preceding instruction that has not yet completed its pipeline write-back stage. This dependency prevents concurrent execution, forcing the pipeline controller to introduce stall cycles, commonly called bubbles, or implement data forwarding to preserve correct computational results.

39. (A) Using branch prediction and delayed branching
Control hazards occur when a processor pipeline cannot determine the next instruction address due to pending branch conditions. To mitigate these performance penalties, modern processors utilize hardware-based branch prediction algorithms to guess execution paths. Additionally, techniques like delayed branching are used to execute useful instructions while the branch target is resolved, minimizing idle pipeline stalls.

40. (D) II and IV
Harvard architectures optimize memory throughput by featuring physically separate paths and storage structures for instruction codes and data variables, enabling simultaneous fetch operations. Additionally, the arithmetic logic unit operates as a vital element during the pipeline execution stage. Conversely, Von Neumann structures share a single physical bus, and advanced general-purpose processors heavily implement pipelining to boost performance.

41. (B) DSPs are optimized for rapid Multiply-Accumulate math operations
Digital signal processors are custom-architected microprocessors designed specifically to process continuous real-world analog signals digitized in real time. Their defining feature is hardware optimized for fast multiply-accumulate operations, which form the mathematical core of filtering, Fourier transforms, and modulation algorithms. Standard microcontrollers, in contrast, prioritize general-purpose input-output control tasks over intensive numeric calculations.

42. (C) Hardware MAC unit
A hardware multiply-accumulate unit is a specialized hardware component integrated into digital signal processors and application-specific instruction-set processors. It computes the product of two numbers and adds that result directly to an accumulator register within a single clock cycle. This specialized pipeline dramatically accelerates mathematical operations crucial for signal processing and matrix calculations.

NODIA

43. (D) They integrate CPU, memory, and peripherals on a single chip
Microcontrollers are highly suited for simple embedded control applications because they integrate the central processing unit, volatile and non-volatile memory, and key peripherals onto

lock ordering, or timeout mechanisms within the RTOS.

82. (C) Message Queue
A message queue is an advanced inter-process communication mechanism ideal for sending structured blocks of data asynchronously between distinct tasks. It utilizes a first-in, first-out buffer managed by the operating system kernel, allowing tasks to write and read messages without blocking each other. This mechanism decouples data producers and consumers, enhancing system modularity and robustness.

83. (B) It holds a single message or pointer to allow rapid data exchange
A mailbox is a lightweight inter-process communication primitive in real-time operating systems characterized by its ability to hold a single message, or more commonly, a memory pointer to a larger data block. This design enables rapid, low-overhead data exchange between tasks, bypassing the need to copy large data payloads directly through kernel memory space.

84. (D) Unidirectional byte-stream communication between related processes
In Unix-like real-time operating systems, a pipe is a fundamental inter-process communication mechanism designed for unidirectional byte-stream data transfer. It connects the standard output of one process directly to the standard input of another. The operating system kernel manages the internal buffer, blocking writers when the pipe is full and readers when it is empty.

85. (A) Synchronizing tasks with multiple discrete event conditions simultaneously
Event registers, or event flags, are highly efficient synchronization primitives that allow a task to wait on multiple discrete event conditions simultaneously. By representing events as individual bits in a binary word, tasks can synchronize based on logical combinations, such as waiting for all flags or any single flag to be set, minimizing kernel scheduling overhead.

86. (C) They are software interrupts notifying a process of an event
Signals function as software interrupts within embedded inter-process communication, allowing the operating system kernel or one process to notify another process of an asynchronous event. When a signal is delivered, the target process pauses its normal execution to run a designated signal handler function, enabling immediate responses to system events or errors.

87. (A) A high-priority task waiting for a resource held by a low-priority task is indirectly blocked by medium-priority tasks preempting the low-priority task.
Unbounded priority inversion is a critical scheduling failure in preemptive real-time systems. It occurs when a low-priority task holds a resource required by a high-priority task, and intermediate medium-priority tasks continuously preempt the low-priority task. This preemption prevents the low-priority task from releasing the resource, indirectly blocking the high-priority task for an unpredictable duration.

88. (D) It temporarily raises the resource-holding low-priority task's priority to match the priority of the highest-priority task waiting for that resource.
The priority inheritance protocol resolves priority inversion by dynamically modifying task priorities. When a high-priority task blocks waiting for a resource held by a low-priority task, the protocol temporarily raises the low-priority task priority to match that of the blocked high-priority task. This prevents medium-priority tasks from preempting it, allowing it to release the resource quickly.

89. (B) PCP prevents chain blocking and deadlocks from nested resources
While basic priority inheritance addresses simple priority inversion, it remains vulnerable to chain blocking and deadlocks when tasks access nested resources. The priority ceiling protocol resolves these issues by assigning a static priority ceiling to each resource. This prevents a task from acquiring a lock unless its priority exceeds the ceilings of all currently held locks.

90. (A) I, II and III
The priority ceiling protocol assigns each resource a ceiling value representing the highest priority of any task that might access it. A task can only acquire a lock if its priority exceeds the ceilings of all active locks held by other tasks, which mathematically prevents deadlocks and bounds priority inversion to at most one critical section.

Downloaded from www.pdf.tube

offering immediate prototyping capabilities and avoiding high mask fees.

17. (D) A chip with configurable logic blocks and programmable interconnects
A field-programmable gate array is a semiconductor device containing a highly flexible matrix of configurable logic blocks, input-output pads, and programmable routing paths. Designers use hardware description languages to define logical connections, allowing the device to implement complex digital circuits. FPGAs provide high performance and hardware parallelism, along with the convenience of post-fabrication reconfiguration.

18. (C) When requiring predictable, deterministic timing for simpler logic functions
Complex programmable logic devices are preferred over field-programmable gate arrays for simpler control tasks requiring highly predictable, deterministic propagation delays. CPLDs feature non-volatile flash memory, allowing near-instantaneous startup behavior upon power application. Their uniform routing structures offer guaranteed timing metrics, making them ideal for boot sequences, bus arbitration, and interface glue logic applications.

19. (B) Using standard cell libraries and pre-characterized logic gates
Semi-custom integrated circuit design relies on standard cell libraries containing pre-designed, pre-characterized logic gates, multiplexers, and flip-flops. Instead of manually drawing individual transistors, designers use automated computer-aided tools to place and route these standardized blocks. This abstraction significantly reduces engineering time, lowers non-recurring expenditures, and maintains high performance compared to full-custom methodologies.

20. (A) P-3, Q-1, R-2, S-4
Different integrated circuit technologies offer distinct trade-offs in digital system design. Full-custom design provides maximum performance and the smallest silicon area but demands high initial development costs. Semi-custom design speeds development by utilizing standard cell libraries. Field-programmable gate arrays provide reconfigurable logic blocks, while complex programmable logic devices offer predictable, non-volatile control logic.

21. (A) Data flow between registers and logical operations on that data
Register-transfer level design describes the operational behavior of digital systems by focusing on the flow of data signals between storage registers. It specifies how data is transferred, manipulated, and processed using combinational logic circuits during clock cycles. This abstraction level bridges high-level architectural specifications and the physical gate-level netlists synthesized for target silicon devices.

22. (C) Multiplexers
Combinational logic circuits generate outputs based solely on current inputs, having no internal memory elements or state feedback loops. Multiplexers are fundamental combinational devices that route a selected input signal to a single output line based on control signals. Other examples include decoders, adders, and logic gates, which operate without clock synchronization or state storage.

23. (A) Sequential logic uses memory elements to store past states
Sequential logic is characterized by its use of memory elements, such as registers or flip-flops, to store historical state information. Consequently, its outputs depend on both current inputs and the previous internal state. Combinational logic outputs, by contrast, depend entirely on current inputs, lacking any memory storage, timing synchronization registers, or historical state dependency.

24. (D) D Flip-Flop
A D flip-flop is the primary sequential memory component used to construct digital registers. It captures and stores a single bit of data from its input on the active edge of a clock signal. By arranging multiple D flip-flops in parallel, designers create multi-bit registers capable of holding binary values stable across clock cycles.

25. (B) To sequence control signals based on states and inputs
In register-transfer level design, a finite state machine serves as the central control unit. It transitionally sequences system states based on current inputs and past states, generating synchronized control signals. These signals direct data transfers and operations within the datapath, ensuring the entire system executes

NODIA

100. (B) III only
Standard Linux utilizes a time-sharing scheduling algorithm designed to optimize average throughput and user responsiveness, making it inherently non-deterministic and unsuitable for hard real-time applications. Conversely, μC-OS uses deterministic priority-based scheduling, RT-Linux prioritizes real-time tasks over the Linux kernel, and Embedded Linux and Windows CE support complex graphical interfaces.

101. (A) Compiling source code on a host to run on a different target architecture
The fundamental purpose of a cross-compiler is to compile software source code on a powerful host development computer, such as a standard PC, to generate executable machine code for a different target processor architecture. This tool is essential because resource-constrained embedded targets often lack the memory, storage, and processing power to run compilers locally.

102. (C) Linker
The linker is a critical software tool in the embedded development toolchain. It combines multiple independent object files generated by the compiler and assembler into a single executable image. During this process, the linker resolves external symbol references, allocates functions and variables to specific physical memory addresses, and generates the final binary file.

103. (A) It loads executable code into a predefined, fixed memory location
The primary function of an absolute loader is loading an executable program binary directly into a predefined, non-configurable physical memory address. Because the program instructions are compiled with absolute memory references, the loader must place the code exactly at those specified addresses to ensure correct execution upon system bootup or hardware initialization.

104. (D) JTAG Debugger or In-Circuit Emulator
A JTAG debugger or in-circuit emulator is an essential hardware tool that interfaces directly with the on-chip debugging resources of a target processor. It allows developers to halt execution, set hardware breakpoints, inspect CPU registers, and step through code in real time without altering the application code or introducing software execution overhead.

105. (B) Object file (.o)
In the GCC development toolchain, the compiler processes individual source files to output corresponding object files. These object files contain compiled machine code and data symbols, but their external references to functions and variables in other files remain unresolved. These unresolved links are later processed and finalized by the linker to produce the executable image.

106. (C) Translating behavioral HDL models into optimized gate-level netlists
Logic synthesis is the automated electronic design process of translating abstract behavioral hardware description language models into an optimized gate-level netlist. During this transition, the synthesis tool optimizes the boolean logic equations for speed, power, and area, and then maps these equations to physical logic gates found within a target technology library.

107. (D) Behavioral states/datapaths and structural gate models
Register-transfer level synthesis bridges the gap between high-level behavioral state machines and structural gate-level circuit models. It interprets behavioral descriptions of registers, multiplexers, and arithmetic units, transforming them into a network of physical gates and flip-flops. This automated synthesis step ensures the hardware implementation accurately reflects the specified algorithmic state transitions.

108. (A) Converts high-level algorithms directly into RTL hardware designs
Behavioral synthesis, also known as high-level synthesis, compiles algorithmic descriptions written in high-level programming languages like C or C++ directly into register-transfer level hardware descriptions. This compiler-like tool automates scheduling, resource allocation, and datapath binding, enabling hardware designers to explore architectural trade-offs rapidly at a high level of functional abstraction.

109. (B) Technology mapping
Technology mapping is the specific phase of logic synthesis that translates an abstract, technology-independent boolean network into a physical netlist. It maps these generic logic expressions to concrete standard cells, such as NAND, NOR, and flip-flop gates, from a specific semiconductor

Click Here to Buy book on Flipkart

manufacturer's library, accounting for physical gate delay, power, and area constraints.

110. (A) Both A and R are true and R is the correct explanation of A.
High-level synthesis dramatically shortens the development cycle of complex custom hardware accelerators by operating at a higher level of abstraction. By compiling algorithmic specifications directly to register-transfer level hardware, HLS allows designers to explore diverse microarchitectural designs, such as unrolling loops or pipelining operations, without manually writing thousands of lines of low-level hardware description language code.

111. (A) Hardware/Software Partitioning of system tasks
System synthesis in hardware/software co-design involves the critical step of hardware/software partitioning. Designers must analyze system specifications to determine which functions should execute as software on a programmable processor and which should be mapped to custom hardware accelerators. This decision balances performance requirements, power constraints, silicon area, and total system cost.

112. (C) Concurrently designing and optimizing hardware and software to meet constraints
The primary goal of hardware/software co-design is the concurrent development and optimization of physical hardware architectures and application software. By designing both domains simultaneously rather than sequentially, engineers can identify performance bottlenecks early, optimize interfaces, and achieve the best trade-off between software flexibility and hardware execution performance while meeting strict design constraints.

113. (D) Identify computationally heavy software code parts for acceleration
In hardware/software co-design, software profiling is used to analyze application execution behavior. It measures where the processor spends execution time and identifies computationally heavy sections of code, often called bottlenecks. This quantitative data guides designers during partitioning, highlighting which algorithms would benefit most from implementation in dedicated, high-speed custom hardware accelerators.

114. (C) Custom hardware blocks or accelerators
During the hardware/software partitioning process, tasks exhibiting extreme computational complexity and strict real-time deadlines are typically assigned to dedicated custom hardware blocks or accelerators. Custom hardware structures, such as coprocessors or FPGAs, execute parallel operations far more efficiently than general-purpose CPUs, ensuring deterministic execution times while staying within tight power envelopes.

NODIA

115. (B) It runs software on simulated hardware models before physical fabrication
Co-simulation plays a vital role in co-design by allowing developers to run and debug application software on simulated models of custom hardware before physical fabrication. This concurrent simulation environment verifies hardware-software interfaces, evaluates overall system performance, and uncovers integration bugs early in the design cycle, significantly reducing development costs and prototyping times.

116. (D) Did we build the system right per specifications?
System verification is a rigorous evaluation process that ensures the implemented design strictly complies with all specified functional, performance, and environmental requirements. It focuses on proving that the hardware and software components were built correctly according to the engineering specifications, using tools like simulation, formal mathematical proofs, and physical hardware-in-the-loop testing.

117. (A) Formal verification techniques
Formal verification is an advanced mathematical technique used to prove that a hardware or software design strictly satisfies its specification. Unlike simulation-based verification, which relies on generating and running extensive test vectors, formal verification uses algorithmic state analysis to exhaustively prove functional properties across all possible states, identifying subtle corner-case design flaws.

118. (C) It runs orders of magnitude faster than software simulation for stack testing
Hardware emulation offers a massive performance advantage over software-based co-simulation by mapping the system design onto high-speed physical programmable logic, such as FPGA

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

arrays. This physical hardware execution runs orders of magnitude faster than software models, enabling developers to run extensive software stacks, operating systems, and real-time test cases that would be computationally impractical to simulate.

119. (A) execute target machine code to evaluate software logic and timing
An instruction set simulator is a software tool used in co-simulation to mimic the behavioral execution of a target processor on a host development computer. It reads and executes compiled machine code instructions, enabling developers to analyze software execution paths, verify functional correctness, and estimate timing characteristics before the physical hardware silicon is fabricated.

120. (B) P-4, Q-1, R-2, S-3
Verification methodologies span different levels of abstraction in embedded systems. Formal verification uses mathematical algorithms to prove design properties exhaustively. Logic simulation applies stimulus test vectors to monitor signal changes over time. Hardware emulation utilizes programmable logic to prototype the design for rapid execution, while in-circuit testing probes physical PCBs to verify assembly integrity.

121. (B) Manual layout and routing cannot handle modern system complexity
Electronic design automation tools are indispensable in modern semiconductor design because manual placement and routing are impossible at sub-micron scales. Modern integrated circuits contain billions of transistors and complex interconnect networks. EDA tools automate logic synthesis, physical layout, routing, and timing verification, allowing engineers to manage design complexity and complete chips within reasonable schedules.

122. (C) A pre-designed, reusable block used to build complex SoC designs
An intellectual property core in system-on-chip design is a pre-designed, reusable logic layout or software block that implements specific functionality, such as a processor core, memory controller, or bus interface. Integrating these pre-verified blocks allows designers to build highly complex chips rapidly, reducing engineering effort, minimizing design risks, and accelerating product time-to-market.

NODIA

123. (D) Synthesizable VHDL or Verilog RTL code
A soft intellectual property core is delivered in the form of synthesizable hardware description language code, typically using VHDL or Verilog. This text-based format provides designers with high flexibility, allowing them to modify the logic and synthesize it for various semiconductor manufacturing processes or target FPGA devices, though it requires subsequent technology mapping.

124. (A) It is a fixed layout mapped to a technology, guaranteeing timing
A hard intellectual property core is delivered as a fully optimized, technology-specific physical layout file, typically in GDSII format. Because its transistor placements and routing paths are fixed, its timing, power, and area characteristics are guaranteed by the vendor. This physical certainty reduces integration risks but limits flexibility to modify the design.

125. (B) Development cost and time-to-market
Design reuse is a strategic methodology that focuses on integrating pre-verified intellectual property cores and standard design blocks into new systems. By avoiding designing complex subsystems from scratch, this practice reduces engineering development costs, simplifies system-level verification, and minimizes design errors, enabling companies to bring products to market much faster.

126. (B) Advanced Microcontroller Bus Architecture (AMBA)
The advanced microcontroller bus architecture is an open-standard, on-chip interconnect specification developed by ARM. It is widely used in system-on-chip designs to establish high-performance communication pathways between various integrated intellectual property cores, such as processors, memory controllers, and peripheral blocks, ensuring standardized compatibility and reliable data transfers.

127. (A) A synthesized netlist combining Soft IP flexibility and Hard IP predictability
Firm intellectual property cores represent an intermediate format between soft and hard IP. They are typically delivered as synthesized, gate-level netlists that have been optimized for a specific technology class but lack final physical layout routing. This configuration combines the

target portability of soft IP with the predictable timing and area of hard IP.

128. (C) An HDL environment applying stimuli to a design and verifying responses
In hardware design automation, a testbench is a specialized simulation environment written in a hardware description language. It encapsulates the design under test, applying defined input stimuli and monitoring output signals to verify functional correctness. This virtual verification setup enables designers to detect and fix logical errors before synthesis or physical prototyping.

129. (D) It reduces time and cost by using standardized components
Integrating commercial off-the-shelf components significantly optimizes embedded system design by utilizing standardized, pre-fabricated hardware and software solutions. By avoiding expensive custom development cycles, designers reduce engineering overhead, lower manufacturing risks, and shorten product development schedules. This approach enables engineering teams to focus their efforts on proprietary software features.

130. (B) I and III
Real-time embedded systems prioritize predictability and deterministic timing over raw data throughput. In soft real-time environments, occasional missed deadlines are tolerated at the cost of degraded performance, whereas hard real-time systems fail catastrophically upon a single miss. Furthermore, these systems do not inherently require multi-core architectures, often running reliably on single-core microcontrollers.

131. (B) The timing variation or deviation of a periodic execution event
Jitter in real-time embedded systems refers to the statistical variation or deviation in the timing of a periodic event, such as task activation, packet transmission, or interrupt response. Minimizing jitter is critical in control systems and signal processing, where highly consistent and predictable timing intervals are required to preserve system stability and data integrity.

132. (D) It continuously interacts with and responds to external environmental stimuli
A reactive embedded system is defined by its continuous interaction with and immediate response to changes in its external operating environment. These systems rely on sensors to monitor physical stimuli, process this data in real time, and generate output signals to actuators, maintaining a continuous feedback loop that operates within strict timing constraints.

133. (A) Both dynamic and static power consumption
To achieve optimal power efficiency in embedded designs, engineers must minimize both dynamic and static power consumption. Dynamic power, caused by active transistor switching, is reduced using clock gating and voltage scaling. Static power, caused by subthreshold leakage currents when transistors are idle, is minimized using power gating and low-leakage manufacturing processes.

134. (C) Throughput
Throughput is a key performance metric defined as the number of operations or tasks a system successfully completes within a specified time interval. While latency measures the time required to complete a single task, throughput focuses on cumulative system efficiency, making it highly important for data processing and communication applications.

135. (A) Software flexibility and hardware performance
Hardware/software partitioning represents a fundamental trade-off between software flexibility and hardware execution performance. Software implementations run on programmable processors, offering easy updates and lower development costs but limited performance. Custom hardware implementations, by contrast, deliver outstanding execution speed and energy efficiency but lack flexibility, requiring complete redesign to modify functionality.

136. (A) Application-Specific Integrated Circuit
Application-Specific Integrated Circuits offer optimal performance and energy efficiency for specialized, computationally intensive tasks such as complex cryptographic algorithms. Unlike general-purpose processors or microcontrollers, these dedicated circuits are custom-designed at the silicon level to execute specific operations, eliminating unnecessary hardware overhead and significantly reducing power consumption under tight constraints.

Downloaded from www.pdf.tube

137. (B) Complex Instruction Set Computer (CISC) systems
Complex Instruction Set Computer architectures utilize microcode stored in a control unit to translate high-level assembly instructions into micro-operations. This design paradigm allows natively executing complex, multi-cycle instructions directly from memory. This approach simplifies assembly-level programming and minimizes code size, distinguishing these systems from Reduced Instruction Set Computer designs that prioritize hardwired single-cycle operations.

138. (B) To buffer frequently used data to reduce access latency
Cache memory serves as a high-speed buffer positioned between the rapid central processing unit and the slower main random-access memory. By storing copies of frequently accessed instructions and data, it exploits spatial and temporal locality. This architecture dramatically minimizes the average latency of memory accesses, preventing the processor from stalling during critical execution cycles.

139. (A) Shared single bus and memory path for instructions and data
The primary bottleneck in Von Neumann architecture arises because instructions and data share a single physical bus and memory path. Since the central processing unit cannot perform instruction fetch and data read or write operations concurrently, execution must be serialized. This physical limitation significantly restricts throughput and creates a persistent memory access bottleneck.

140. (A) I, II and IV
Application-Specific Instruction-set Processors bridge the gap between custom silicon and general-purpose chips, while digital signal processors use hardware loop control to minimize branching overhead. General-purpose processors maximize throughput across unpredictable workloads. Microcontrollers integrate various peripheral interfaces directly on-chip, making statements describing them as lacking these components completely incorrect in modern embedded design.

141. (D) Structural hazards caused by concurrent memory accesses
Harvard architecture features physically separate storage and signal pathways for instructions and data. This separation allows the processor to access instructions and read or write data concurrently during the same clock cycle. By eliminating memory resource conflicts, this design inherently prevents structural hazards that frequently cause pipeline stalls in shared-bus Von Neumann systems.

142. (C) All main system components integrated together on a single silicon die
A System-on-Chip represents a highly integrated microelectronic design that consolidates all major components of a computer or electronic system onto a single silicon substrate. This integration typically encompasses processor cores, memory modules, peripheral controllers, and interfaces. This consolidated approach minimizes physical board space, lowers power consumption, and increases overall signal transmission speed.

143. (B) It enables manual transistor-level layout optimization for efficiency
Full-custom very-large-scale integration design involves the manual placement and routing of individual transistors and connections on a silicon wafer. This labor-intensive methodology allows engineers to optimize physical placement for maximum speed, minimal area, and optimal power efficiency. It provides unparalleled performance gains, although it requires high non-recurring engineering costs and longer development cycles.

NODIA

144. (D) Macrocells consisting of Sum-of-Products logic and flip-flops
Complex Programmable Logic Devices are built around non-volatile macrocells that implement logic functions using programmable Sum-of-Products arrays paired with flip-flops. This configuration allows for highly predictable timing characteristics and rapid startup times. These devices differ structurally from field-programmable gate arrays, which rely on volatile look-up tables and extensive routing channels for logic implementation.

145. (A) Programmable Look-Up Tables (LUTs)
Field-programmable gate arrays utilize programmable look-up tables to implement complex combinatorial logic. These structures

184. (A) To manage context switch processes before and after the ISR
Trampoline or wrapper functions in real-time operating systems manage the transition between task execution and interrupt contexts. These routines save volatile registers before handing control to the user's interrupt service routine and subsequently coordinate with the scheduler to trigger a context switch if a higher-priority task became ready during the interrupt.

185. (B) A block of code accessing shared resources that needs exclusive execution
A critical section of code represents any segment of an embedded application that accesses shared, mutable resources, such as global variables, hardware registers, or memory buffers. To prevent data corruption and race conditions, these sections require exclusive execution, ensuring only one task can access the resource at any given time.

186. (B) Disabling all global interrupts temporarily
Temporarily disabling all global interrupts provides the simplest method to protect a critical section in single-processor systems. By preventing any hardware interrupts from firing, the active task blocks the scheduler from executing context switches. This ensures uninterrupted execution, although it increases overall interrupt latency if held for too long.

187. (A) A binary semaphore supporting ownership and priority inheritance
A mutex is a specialized binary semaphore designed to manage mutual exclusion. Unlike basic semaphores, a mutex features the concept of task ownership, meaning only the task that acquired the mutex can release it. Additionally, mutexes incorporate priority inheritance protocols to mitigate priority inversion during concurrent execution.

188. (C) Message Queue
Message queues are ideal for resolving the classic producer-consumer problem in embedded systems. This mechanism provides a thread-safe, first-in-first-out buffer that allows the producer task to post data items asynchronously while the consumer task blocks until data arrives, decoupling execution speeds and managing data synchronization seamlessly.

189. (D) Asynchronous notification triggering process signal handlers
In POSIX-compliant operating systems, a signal serves as an asynchronous notification delivered directly to a running process to report a specific event. When a signal is received, the operating system interrupts the normal execution flow of the target process to run a designated signal handler function, enabling rapid event response.

190. (C) A low-priority task holds a resource needed by a high-priority task, and a medium-priority task preempts the low-priority task
Priority inversion occurs when a low-priority task holds a shared resource required by a high-priority task. Before the low-priority task can release the resource, a medium-priority task preempts it, as the medium task does not require the resource. This indefinitely delays the high-priority task, violating real-time scheduling constraints.

191. (B) PCP prevents deadlocks and chain blocking before blocking occurs
The Priority Ceiling Protocol improves upon the Priority Inheritance Protocol by assigning a static priority ceiling to each shared resource equal to the highest priority of any task that may lock it. This mechanism prevents mutual exclusion deadlocks and limits chain blocking to a single critical section before any task blocks.

192. (D) Implemented as software callbacks executed on RTOS tick interrupts
Embedded software timers provided by a real-time operating system are implemented as kernel-managed callbacks. They execute within the context of a dedicated timer daemon or directly inside the system tick interrupt handler, making their timing accuracy dependent on the system tick period and the execution priorities of active tasks.

193. (A) It causes allocation failures even when total free memory is enough
Memory fragmentation is a major hazard in long-running embedded systems utilizing dynamic memory allocation. Over time, repeated allocation and deallocation break the heap into non-contiguous segments. This can cause subsequent allocation requests for large blocks to fail, even when the total aggregate amount of free memory is more than sufficient.

Click Here to Buy book on Amazon

155. (A) The logic path with the maximum delay between two registers
The critical path in a digital circuit represents the longest continuous path of combinational logic gates between any two sequential registers. The cumulative propagation delay along this path determines the minimum clock period required for safe operation, as data must propagate through this entire chain before the next active clock edge arrives.

156. (C) Two instructions require the use of the same hardware resource simultaneously
Structural hazards manifest in pipelined processors when multiple instructions executing in different stages attempt to access the same physical hardware resource concurrently. This situation frequently occurs when a system uses a single unified memory for both instructions and data, or shares a single execution unit, forcing the scheduler to stall the pipeline.

157. (D) Operand Forwarding (Data Bypassing)
Operand forwarding, also called data bypassing, resolves data hazards in pipelined processors by routing execution results directly from the outputs of pipeline registers to the inputs of the arithmetic logic unit. This mechanism bypasses the write-back stage, allowing subsequent instructions to access needed operands immediately without waiting for register file write cycles.

158. (C) Issuing multiple instructions to parallel execution units
Superscalar processor architectures increase instruction execution rates by fetching, decoding, and dispatching multiple independent instructions concurrently to parallel execution units. This design relies on instruction-level parallelism, dynamic scheduling, and multiple execution pipelines to complete more than one instruction per clock cycle, exceeding the fundamental performance limits of single-scalar pipelines.

159. (B) Integrated timer blocks and deterministic interrupt latencies
Microcontrollers are optimized for real-time control through the inclusion of dedicated hardware peripherals like programmable timers, PWM outputs, and analog-to-digital converters on the same silicon die. Furthermore, their interrupt controllers are engineered to provide deterministic response latencies, ensuring critical events are processed with minimal and predictable timing variations.

NODIA

160. (A) Both A and R are true and R is the correct explanation of A.
Microcontrollers rely on embedded, non-volatile Flash memory for program storage because it retains critical software instructions even after complete power loss. This capability is essential for standalone controllers, as it guarantees that the execution program remains intact and launches instantly upon system power-up, making both statements correct and logically linked.

161. (A) Data transmission in only one fixed direction
Simplex represents a serial communication mode where data transmission is strictly unidirectional, meaning signals flow from a transmitter to a receiver with no mechanism for return communication. This configuration requires only a single physical transmission channel and is utilized in systems where bidirectional feedback is completely unnecessary or physically impossible.

162. (C) By timing the Start bit, data bits, and Stop bit sequences
A universal asynchronous receiver-transmitter receiver establishes synchronization with incoming data streams by detecting the transition of the start bit. Using a local clock running at a multiple of the baud rate, the receiver samples successive data bits at predefined intervals and identifies the sequence end upon receiving the stop bit.

163. (A) Signal degradation and noise on single-ended physical lines
The RS-232 interface uses single-ended signaling, where logic levels are defined relative to a common ground connection. This configuration makes the physical signals highly susceptible to electromagnetic interference, capacitive loading, and ground potential differences over distance. Consequently, these factors degrade signal integrity and restrict reliable transmission to approximately fifteen meters.

164. (D) Transmitting differential voltage signals over twisted pairs
RS-485 provides superior noise immunity in harsh industrial environments by employing

function as small, high-speed memories that store the truth table of a desired Boolean function, producing the correct output for any given input combination. This flexible architecture allows users to configure and reconfigure complex digital circuits dynamically without altering hardware.

146. (C) Volatility; configuration is lost without power
Static random-access memory technology is inherently volatile, meaning it requires continuous electrical power to retain its state. Because SRAM-based field-programmable gate arrays lose their internal configuration when powered down, they must reload their design parameters from an external non-volatile memory source, such as a Flash chip or EEPROM, immediately upon system boot.

147. (A) Route data from multiple source paths into a single target register
Multiplexers function as digital switches within a custom processor datapath to select one of several input signals and route it to a single output line. Controlled by select lines from the control unit, these devices enable efficient data routing from various source registers, memory outputs, or buses into a specific destination register or ALU input.

148. (D) Setup time
In synchronous sequential logic, setup time represents the absolute minimum duration that an input data signal must remain stable before the active edge of the clock signal arrives. Ensuring the data is stable during this window allows the internal feedback loops of the register or flip-flop to settle and reliably capture the correct logical state.

149. (B) The device enters metastability with unstable outputs
Violating setup or hold time constraints in a flip-flop prevents the internal latching circuit from settling into a stable logical high or low state within the specified propagation delay. This unstable condition is known as metastability, where the output hovers between logical states, potentially causing downstream logic failures and unpredictable system behavior.

150. (A) I, III and IV
The critical path delay defines the maximum clock frequency of synchronous circuits, while Moore and Mealy machine outputs depend on specific state configurations. Pipelining actually reduces the critical path delay by partitioning logic into smaller stages. Resource sharing typically increases delay due to multiplexing overhead, making statements advocating for increased pipelining delay or resource-sharing speedups incorrect.

151. (D) Defining state transitions and datapath steps synchronously
Algorithmic State Machine charts describe finite state machines by clearly separating controller state transitions from synchronized datapath actions. Unlike standard state diagrams, these charts present a structured flowchart representation that directly maps to hardware execution blocks, ensuring that state transitions and output signals are generated in strict alignment with clock boundaries.

152. (A) Next-state combinational logic
In a finite state machine, the next-state combinational logic block processes the current state stored in memory along with any external input signals to determine the upcoming state. This logic does not store information itself; instead, it outputs the target state code to the input of the state memory registers before the next clock edge.

153. (B) Multiply and Accumulate
Digital signal processing algorithms relies heavily on the multiply-and-accumulate operation to calculate vector dot products, convolutions, and filtering equations efficiently. The specialized MAC unit performs a multiplication of two input values and adds the product to an accumulator register in a single clock cycle, dramatically acceleration signal processing throughput.

154. (B) Share a single ALU across clock cycles to reduce physical silicon area
To optimize a processor design for minimum silicon area, developers can implement resource sharing by utilizing a single arithmetic logic unit across multiple clock cycles. Although this sequential processing increases execution time for complex operations, it eliminates the need for redundant hardware components like multiple adders or multipliers, significantly reducing physical chip size.

Downloaded from www.pdf.tube

174. (C) Scatternet
A Bluetooth scatternet is formed by interconnecting multiple individual piconets. In this configuration, a device participates in more than one piconet by sharing its time dynamically, acting as a master in one network and a slave in another. This structure enables broader ad-hoc wireless networking across multiple nodes.

175. (B) Full task preemptibility, bounded execution, and low latencies
Real-time operating system kernels prioritize execution predictability and determinism over overall throughput. They feature full task preemptibility, bounded interrupt latency, and fast context switching. This design ensures that high-priority, time-critical tasks can interrupt lower-priority execution immediately, satisfying strict deadline constraints that general-purpose operating systems cannot guarantee.

176. (D) From the Running state to the Blocked state
When a running task invokes a delay function, it voluntarily relinquishes control of the processor. The kernel then transitions the task from the running state to the blocked state, placing it in a delay queue. It remains there until the specified time interval elapses, allowing other ready tasks to execute.

177. (A) When the running task explicitly yields control or blocks
In a non-preemptive real-time operating system, the active task retains control of the processor until it voluntarily yields execution. This cooperative scheduling paradigm requires tasks to explicitly call a blocking system function or yield control, preventing the scheduler from interrupting execution even if a higher-priority task becomes ready.

178. (C) The current task context is saved and the ready task runs instantly
Under preemptive scheduling, when an interrupt or system event causes a higher-priority task to enter the ready state, the kernel immediately intervenes. It suspends the currently running low-priority task, saves its processor context to its task control block, and loads the context of the high-priority task, executing it instantly.

NODIA

179. (A) It guarantees scheduling feasibility if total processor utilization is below approximately 69%
Rate Monotonic Scheduling is a static-priority scheduling algorithm where priority is inversely proportional to task period. A key limitation is that for a set of independent, periodic tasks, schedulability is guaranteed only if total processor utilization remains below the analytical bound, which approaches approximately sixty-nine percent as the number of tasks increases.

180. (A) IV, II, III, I
A context switch in a preemptive scheduler begins when an interrupt or timer tick triggers execution. The kernel then saves the active task's registers into its task control block, after which the scheduler selects the highest priority ready task from the queue. Finally, it restores the registers of the selected task to resume execution.

181. (B) Missed deadlines are tolerated occasionally, though performance degrades
Soft real-time systems differ from hard real-time systems in how they handle timing violations. In a soft real-time system, missing a task deadline degrades overall system performance but does not result in catastrophic hardware damage or system failure. Consequently, these architectures are suitable for applications like multimedia streaming or network routing.

182. (C) Calling a blocking RTOS delay function or waiting on a mutex
Interrupt service routines must execute as quickly as possible to maintain system responsiveness and must never invoke blocking functions, such as delays or mutex acquisitions. Since interrupts do not run in a standard task context, blocking within an ISR can freeze the operating system kernel and cause unpredictable system-wide lockups.

183. (D) Based on a hardware-defined interrupt priority scheme
When multiple hardware interrupts assert simultaneously, the central processing unit resolves the conflict using a hardware-defined priority scheme. The interrupt controller evaluates the priority level assigned to each interrupt line and directs the processor to execute the service routine associated with the highest priority request while deferring the others.

differential signaling over a balanced twisted pair of wires. By defining logic states based on the voltage difference between two complementary lines rather than ground, the receiver naturally rejects common-mode noise, allowing long-distance, high-speed multi-point communication.

165. (B) Identify and configure new peripheral devices attached to the bus
Universal Serial Bus enumeration is the automated process of detecting, identifying, and configuring newly connected peripheral devices. Upon connection, the host controller queries the device for its descriptors, assigns a unique bus address, and loads the appropriate software drivers, enabling seamless hot-plugging capability without requiring system reboots.

166. (C) Isochronous
Isochronous transfers within the Universal Serial Bus protocol prioritize continuous, real-time data delivery over absolute reliability. This transfer mode guarantees constant bandwidth and bounded latency, making it ideal for streaming audio or video data where minor packet dropouts are acceptable, but any delivery delays would disrupt the user experience.

167. (D) Direct Memory Access (DMA) transactions between device nodes
The IEEE 1394 architecture supports peer-to-peer communication, enabling connected nodes to initiate direct memory access transactions with one another without routing data through a central host computer. This capability distinguishes it from host-centric architectures like USB, facilitating high-speed, low-latency data transfers directly between digital peripherals like cameras and drives.

168. (A) Its hardware-defined 48-bit MAC (Media Access Control) address
An Ethernet network interface controller is assigned a unique, hardware-defined forty-eight-bit Media Access Control address during manufacturing. This globally unique identifier resides in non-volatile memory on the device and operates at the data link layer to ensure packets are routed to the correct physical destination within a local network segment.

169. (B) To isolate collision domains by routing frames to target ports
Network switches replace traditional hubs to improve Ethernet network efficiency by isolating individual collision domains. Unlike hubs, which broadcast incoming data frames to every physical port, switches analyze destination MAC addresses and forward frames only to the specific port connected to the targeted device, eliminating packet collisions and optimizing bandwidth.

170. (A) P-3, Q-4, R-1, S-2
Synchronous protocols include the two-wire multi-master inter-integrated circuit bus and the serial peripheral interface, which relies on individual chip select lines. For robust industrial networks, the controller area network uses differential signaling, while the universal serial bus features a tiered, host-centric star topology, matching all communication protocols to their definitions.

171. (A) Half-duplex, line-of-sight, point-to-point transmission
Infrared Data Association protocols utilize directed infrared light beams to establish short-range, point-to-point communication links. Because this technology requires a clear, unobstructed line of sight between the transmitter and receiver diodes, it operates in a half-duplex manner, allowing data exchange in only one direction at any given moment.

172. (C) CSMA/CA (Collision Avoidance)
The IEEE 802.11 standard employs carrier sense multiple access with collision avoidance to manage shared wireless mediums. Since wireless transceivers cannot detect collisions while transmitting, devices listen to the channel and wait for a random backoff interval after it becomes clear, minimizing the probability of simultaneous packet transmissions.

173. (D) Delivery Traffic Indication Message sleep states
To conserve battery power, wireless devices use the Delivery Traffic Indication Message protocol built into the IEEE 802.11 standard. This mechanism allows mobile stations to enter a low-power sleep state and wake up periodically to check access point beacons for buffered multicast or unicast data, reducing transmitter power consumption.

Click Here to Buy book on Flipkart

194. (C) Pre-allocated blocks of fixed-size memory that can be allocated in constant time
Memory pools provide deterministic memory management in real-time embedded systems by utilizing pre-allocated arrays of fixed-size blocks. Because all blocks are identical, allocation and deallocation operations run in constant time without searching the heap. This approach completely eliminates physical memory fragmentation and guarantees predictable response times for critical tasks.

195. (A) Tickless idle mode suppressing timer ticks when tasks are idle
Tickless idle mode is an effective operating system-level power-saving strategy that suppresses periodic timer tick interrupts when the processor is idle. Instead of waking up the CPU at every tick interval, the kernel calculates the sleep duration until the next scheduled task and configures a hardware timer to wake the system then.

196. (D) It can be stored in and executed directly from non-volatile memory (ROM/Flash)
A ROMable kernel is specifically compiled to reside in and execute directly from non-volatile memory, such as Read-Only Memory or onboard Flash. This architecture eliminates the requirement to copy the operating system image into random-access memory during boot, optimizing memory usage and making it ideal for deeply embedded systems.

197. (B) Kernel space
In monolithic operating system architectures like Embedded Linux, device drivers reside in kernel space. This design grants drivers direct, unrestricted access to the underlying hardware registers, physical memory, and system interrupts, ensuring low latency and high execution speed, though a driver crash can compromise the entire operating system stability.

198. (C) It runs a microkernel for real-time tasks with Linux in background
RT-Linux achieves hard real-time capabilities by introducing a small, highly efficient real-time microkernel beneath the standard Linux operating system. This microkernel intercepts hardware interrupts directly, executing time-critical real-time tasks with deterministic latency while running the standard, non-real-time Linux operating system as a low-priority idle task in the background.

199. (D) Providing a familiar Win32 API within a real-time operating system environment
Windows CE was developed as a modular, real-time operating system designed for embedded systems with limited resources. It gained popularity by offering developers a familiar Win32 application programming interface, allowing software engineers to apply desktop Windows development methodologies and tools while still achieving deterministic, real-time execution on specialized hardware targets.

200. (A) III, II, I, IV
The embedded software build process begins with the preprocessor handling compiler directives and macros. Next, the cross-compiler translates the source files into target-specific assembly or object code. The linker then combines these object files and resolves memory addresses, before the final hex or binary executable image is generated.

201. (B) A JTAG emulator/debugger
A JTAG emulator or debugger is essential for bare-metal embedded development, enabling direct control over the target processor. This hardware tool connects to the chip's internal debug port, allowing developers to halt execution, step through code, inspect registers, and read or write directly to physical memory in real time.

202. (B) To define the target board memory layout and place code sections
A linker script serves as a vital configuration file in the embedded toolchain, defining the exact physical memory layout of the target board. It instructs the linker on where to allocate specific code and data sections, such as executable code, initialized variables, and stack space, within RAM and Flash boundaries.

203. (A) Uninitialized global and static variables zeroed at system boot
The .bss section of an executable image holds global and static variables that are declared without explicit initial values. To optimize file size, these variables are not stored in the compiled binary image; instead, the system startup code allocates and clears this memory region to zero immediately during the boot sequence.

Downloaded from www.pdf.tube

2022

10. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).

Assertion (A): The Karhunen-Loève Transform (KLT) is statistically optimal for data compression among all linear transforms.

Reason (R): The KLT basis functions are fixed and independent of the input image data, making them mathematically universally efficient.

In light of the above statements, choose the correct answer from the options given below:

(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2011

11. Homomorphic filtering effectively separates illumination and reflectance components by applying which initial mathematical operation to the image?

(A) Fourier transform
(B) Natural logarithm
(C) Highpass filtering
(D) Exponential function

2016

12. If a noise histogram in an image exhibits a single sharp peak with a right-skewed tail, which noise probability density function most likely models this degradation?

(A) Uniform noise
(B) Rayleigh noise
(C) Gaussian noise
(D) Salt-and-pepper noise

2017

13. What is the primary disadvantage of using basic inverse filtering for image restoration when the image contains additive noise?

(A) It amplifies noise components at frequencies where the degradation function is near zero.
(B) It significantly blurs the original image details and fails to recover high-frequency edges.
(C) It requires highly precise and complex prior knowledge of the power spectrum of the noise.
(D) It mathematically assumes that the noise is multiplicative and non-stationary in nature.

NODIA

2017

14. When performing geometric spatial transformations on an image, which gray-level interpolation technique assigns the value of the closest integer coordinate pixel to the transformed location without any weighting?

(A) Bilinear interpolation technique
(B) Bicubic interpolation technique
(C) Nearest-neighbor interpolation
(D) Spline interpolation technique

2015

15. In the HSI color model, which component specifically represents the dominant wavelength of light perceived by the human eye?

(A) Intensity
(B) Saturation
(C) Luminance
(D) Hue

2010

16. What is the effect of applying intensity slicing in pseudocolor image processing?

(A) Converting a true-color image into grayscale using weighted RGB component averages
(B) Equalizing the color histogram of the individual RGB channels completely independently
(C) Assigning distinct colors to ranges of gray levels in a monochrome image
(D) Smoothing high-frequency color noise while preserving critical spatial luminance edges

2002

17. Which fundamental morphological operation has the effect of shrinking foreground objects and stripping away boundary pixels?

(A) Dilation
(B) Erosion
(C) Closing
(D) Hit-or-Miss Transform

2012

18. The morphological top-hat transformation is primarily utilized for which specific image processing task?

(A) Extracting the external boundary of an arbitrary binary object
(B) Identifying and labeling connected components in binary images
(C) Thinning a binary foreground object to its structural skeleton
(D) Enhancing local detail under non-uniform scene illumination

214. (C) Hard IP cores (GDSII layouts)
Hard IP cores are delivered as physically mapped, optimized layout files, typically in GDSII format, tailored to a specific manufacturing process. Because the physical placement and routing of transistors are pre-determined, these cores offer the highest predictability regarding timing, area, and power consumption, though they completely lack design flexibility.

215. (D) Designing reusable, modular software libraries for multiple new systems
Code reuse in embedded systems development involves creating modular, well-documented software components designed for use across multiple distinct projects. By implementing standardized interfaces and hardware abstraction layers, developers can reuse pre-verified drivers and algorithmic libraries, which reduces overall engineering costs and significantly speeds up time-to-market.

216. (A) ARM Advanced Microcontroller Bus Architecture
The Advanced Microcontroller Bus Architecture standard is a widely adopted system-on-chip interconnect specification. It defines high-performance bus protocols, such as AHB and AXI, enabling seamless integration of various intellectual property blocks, processor cores, and memory controllers on a single chip, while optimizing on-chip communication bandwidth and efficiency.

217. (B) Designing hardware and software in parallel with iterative feedback loops
Hardware-software co-design methodologies emphasize the concurrent development of hardware architectures and software applications. By utilizing iterative feedback loops and joint performance evaluations, this approach enables design teams to optimize the overall system architecture, resolve integration issues early, and achieve the best balance of performance, power, and cost.

218. (B) Higher execution performance and lower power at the cost of flexibility
Offloading computationally intensive tasks to a dedicated hardware accelerator significantly increases execution speed and energy efficiency compared to running software on a general-purpose processor. However, this implementation inherently sacrifices flexibility, as the custom hardware cannot be easily updated or repurposed to support new algorithms after the chip has been manufactured.

219. (A) Reusing pre-verified IP cores and commercial off-the-shelf systems
To meet tight market deadlines, embedded system developers heavily rely on pre-verified intellectual property cores and commercial off-the-shelf components. This design strategy avoids the high costs and long development cycles associated with designing custom hardware or software from scratch, enabling rapid product assembly, verification, and reliable deployment.

220. (A) P-2, Q-4, R-1, S-3
Cross-compilers translate high-level source code into target-specific binaries, which the linker combines and maps to memory addresses. The loader then transfers these executable files into target memory for execution, while debuggers enable step-by-step program execution and variable inspection on the hardware, establishing the correct build sequence.

221. (D) Earliest Deadline First (EDF)
Earliest Deadline First is a dynamic scheduling algorithm that calculates task priorities at run-time based on remaining deadlines. The scheduler always prioritizes the ready task closest to its deadline, maximizing processor utilization up to one hundred percent, unlike static scheduling algorithms which are limited by fixed utilization bounds.

222. (C) Its physical volume footprint, power usage, and hardware reliability
Embedded systems deployed in aerospace applications must be designed to withstand extreme environments where physical repair is impossible. Consequently, developers evaluate these systems primarily on physical volume, power consumption, and hardware reliability, prioritizing fault tolerance and radiation hardening over high-level software frameworks or aesthetic appeal.

223. (B) The RTOS permits deterministic multitasking via preemptive schedules
A real-time operating system offers a significant advantage over a bare-metal super-loop by providing a highly deterministic, preemptive scheduler. This scheduler ensures that high-priority tasks run precisely when events

Click Here to Buy book on Amazon

or application program into active memory to begin execution.

246. (B) To maintain the execution state, priority, and context of a task
The Task Control Block is a vital data structure in a real-time operating system that maintains the run-time state of an individual task. It stores critical parameters such as task priority, stack pointer, program counter, and processor registers, enabling the scheduler to execute seamless context switches.

247. (D) The optimal partitioning of tasks to meet performance constraints
A primary challenge in hardware-software co-design is the optimal partitioning of tasks between hardware execution and software programs. Designers must analyze performance, power, and cost trade-offs to decide which components require dedicated hardware acceleration and which can run as software on general-purpose processor cores.

248. (A) A gate-level netlist of interconnected logic gates
Logic synthesis is the electronic design automation process that translates a high-level register-transfer level description into an optimized gate-level netlist. This netlist consists of interconnected logic gates and flip-flops from a specific technology library, serving as the basis for physical placement and routing on silicon.

249. (B) Formal Verification
Formal verification is a mathematical verification methodology that proves a digital design adheres to its specified properties across all possible operational states. Unlike simulation-based testing, it does not execute test cases; instead, it uses mathematical proofs to guarantee the complete absence of targeted bugs.

250. (A) I, II, III, IV
The hardware design flow begins with system specification, followed by behavioral simulation to verify functional algorithms. Once validated, the design undergoes logic synthesis to generate a gate-level netlist, which is then processed through place and route tools to define the physical layout on silicon.

251. (A) Hard IP
A Hard IP core is an intellectual property block delivered as a physically mapped and routed layout, typically in GDSII format, optimized for a specific semiconductor manufacturing process. This format provides highly predictable timing and power characteristics, but lacks the flexibility for modifications or porting.

NODIA

252. (C) ARM
The Advanced Microcontroller Bus Architecture standard was introduced by ARM to facilitate on-chip communication within complex system-on-chip designs. AMBA provides standard bus interfaces, such as APB, AHB, and AXI, which enable designers to integrate diverse processor cores and peripheral blocks on a single chip.

253. (D) Full-Custom ASIC
For high-volume consumer products manufactured in the millions, full-custom ASICs offer the most cost-effective and efficient solution. Despite high non-recurring engineering costs, the low unit cost, minimal silicon area, and exceptional power efficiency make full-custom silicon ideal for maximizing high-volume profitability and device performance.

254. (C) The real-time task continues executing, deferring standard Linux run
In RT-Linux, the real-time microkernel runs at a higher priority than the standard Linux kernel. Consequently, when a standard Linux process requests processor time while a real-time task is active, the real-time task continues executing uninterrupted, deferring the standard Linux execution until real-time tasks complete.

255. (B) Pipe
A pipe is an inter-process communication mechanism that behaves as a first-in, first-out buffer for byte streams. It allows one process to write data to the stream while another reads it sequentially, providing a synchronized communication channel between related processes in embedded systems.

256. (D) The statistical timing variance in task start or completion times
Jitter in real-time systems refers to the statistical timing variation in the activation, start, or completion times of a periodic task. Minimizing jitter is critical for real-time control loops, as unexpected timing fluctuations can degrade system stability, disrupt synchronization, and introduce execution errors.

the collision, stop transmission immediately, and wait a random backoff time to retry.

235. (A) 2.4 GHz and 5.0 GHz ISM bands
The IEEE 802.11 Wi-Fi standard operates in the unlicensed 2.4 GHz and 5.0 GHz industrial, scientific, and medical radio bands. These frequency bands allow local wireless networking without regulatory licensing, although they are shared with various devices like microwaves and Bluetooth equipment.

236. (C) The system scheduler selects it based on priority and availability
In a real-time operating system, a task transitions from the ready state to the running state when the system scheduler selects it for execution. This selection is based on task priority and processor availability, resulting in a context switch that loads the task's state.

237. (D) A function that can be safely called by multiple concurrent threads or tasks without data corruption
A reentrant function can be executed by multiple concurrent threads or tasks simultaneously without data corruption. To achieve this, the function must avoid using global or static variables, rely exclusively on local variables allocated on the caller's stack, and use mutual exclusion for shared resources.

238. (C) Global or static variables not protected by mutual exclusion methods
To ensure a function is reentrant, developers must avoid using global or static variables that are not protected by mutual exclusion mechanisms. Unprotected shared variables are susceptible to concurrent modification by multiple threads, leading to race conditions, data corruption, and unpredictable software behavior.

239. (B) A hardware timer resetting the CPU when software fails to clear it in time
A watchdog timer is a hardware safety mechanism that protects embedded systems from software lockups or infinite loops. During normal operation, the software must periodically clear or service the timer; if the software hangs and fails to reset the timer before it overflows, the watchdog triggers a system reset.

240. (D) Mailbox
An RTOS mailbox is an inter-process communication mechanism that allows tasks to exchange data by passing a pointer to a message object. Unlike basic semaphores, which only signal events, mailboxes enable synchronized, structured data sharing, allowing receiving tasks to block until a message is deposited.

241. (A) Multiple tasks waiting for resources held by each other in a circle
A deadlock is an execution failure that occurs when two or more tasks are blocked permanently, each waiting for a resource held by another in a circular chain. Because none of the tasks can release their resources, execution halts, requiring preventative algorithms or a system reset.

242. (C) Prove via scheduling analysis that task deadlines will be met under worst-case workloads
Determining the worst-case execution time of tasks is critical in hard real-time systems to perform rigorous schedulability analysis. This analysis mathematically proves that all tasks will meet their deadlines under the worst-case workloads, ensuring system predictability and preventing catastrophic timing failures in safety-critical deployments.

243. (A) Event Flag and Event Register structures
Event flags and registers are advanced synchronization mechanisms designed to handle complex, multi-condition triggers in real-time systems. These structures allow a task to block until multiple specific events occur, supporting logical configurations such as waiting for a combination of conditions before resuming execution.

244. (D) Extensive networking, file system, and GUI software interfaces
Compared to lightweight kernels like uC-OS, Embedded Linux offers extensive software services, including networking stacks, complex file systems, and graphical user interfaces. While it requires significantly more memory and has higher scheduling latency, it provides a comprehensive software ecosystem for feature-rich embedded applications.

245. (B) Initializing hardware systems and loading applications into active memory
A bootloader is a specialized program that runs immediately upon hardware reset. It is responsible for initializing low-level system hardware, such as clocks, memory controllers, and peripherals, before loading the main operating system kernel

Downloaded from www.pdf.tube

267. (A) To accelerate computationally heavy, time-critical software tasks
In hardware-software co-design, an Application-Specific Integrated Circuit functions as a high-performance coprocessor or accelerator. It offloads computationally intensive, time-critical tasks from the primary software execution unit, enabling high throughput and energy efficiency that are impossible to achieve through software execution alone on general-purpose processors.

NODIA

268. (C) Streaming real-time execution metrics using hardware trace modules
Streaming real-time execution metrics through dedicated hardware trace modules is the least intrusive debugging method. Unlike software breakpoints or printf debugging, which alter execution timing, hardware trace utilizes separate monitoring channels on the silicon to capture program flow in real time without introducing processing overhead or halting the system.

269. (D) High portability across different FPGA families or standard-cell ASIC processes
Soft IP cores offer superior portability because they are delivered as synthesizable HDL behavioral source code. This format allows designers to target diverse FPGA families or standard-cell ASIC manufacturing technologies using standard logic synthesis tools, making the design independent of specific hardware vendors or physical cell libraries.

270. (C) Verification checks specification matching, while validation tests user needs
Verification evaluates whether a product conforms to its specified technical requirements, ensuring the system is built correctly. In contrast, validation assesses the final product against user needs and operational requirements to confirm it serves its intended purpose, making both processes distinct but complementary within system design methodologies.

****

257. (C) IEEE 802.15.1
The IEEE 802.15.1 standard defines the physical and media access control specifications for wireless personal area networks, corresponding to Bluetooth technology. This standard enables short-range, low-power ad-hoc communication between mobile phones, computers, and peripheral devices, operating in the unlicensed 2.4 GHz spectrum.

258. (C) Providing physical electrical routing pathways to connect logic blocks
Programmable interconnects within a field-programmable gate array are responsible for routing signals between configurable logic blocks, input-output pads, and dedicated hardware components. This flexible routing matrix allows designers to establish electrical connections dynamically to implement custom digital circuits on the FPGA substrate.

259. (A) It simplifies instruction set updates by altering microcode control store
A microprogrammed control unit simplifies instruction set architecture modifications by storing control sequences as microcode in a control store. Updating or expanding instructions requires modifying the microcode memory rather than redesigning the physical combinational hardware, offering superior flexibility compared to hardwired control unit designs.

260. (D) Hardware manages loop counts and branches with no software overhead
Zero-overhead looping is a specialized hardware feature found in digital signal processors. It utilizes dedicated registers to track loop counters, boundary addresses, and branching decisions automatically, eliminating the standard software instruction overhead associated with decrementing counters, checking conditions, and branching at the end of each iteration.

261. (C) By using non-destructive bitwise arbitration based on message priority identifiers
The Controller Area Network bus resolves collisions using non-destructive bitwise arbitration. When multiple nodes transmit simultaneously, they compare their message identifiers bit-by-bit; dominant bits override recessive bits, allowing the highest priority message to continue transmission uninterrupted while lower priority nodes temporarily back off.

262. (B) 480 Mbps
The USB 2.0 High-Speed specification defines a maximum theoretical signaling rate of 480 megabits per second. This standard introduced significant performance improvements over USB 1.1, enabling faster data transfers for external storage drives, media devices, and high-bandwidth peripherals while maintaining backward compatibility.

263. (D) The CPU general-purpose registers, Program Counter, and Stack Pointer
The runtime context of a task in a real-time operating system minimally consists of its active execution state. This includes the CPU general-purpose registers, the Program Counter, and the Stack Pointer, which must be saved during a context switch to resume execution without data loss.

264. (A) Stack pointers grow beyond bounds, corrupting adjacent memory space
A stack overflow occurs when a task's call stack exceeds its allocated memory boundary. This issue typically arises from deep recursion or large local variables, causing the stack pointer to write into adjacent memory. This corrupts critical task variables or OS structures, resulting in system crashes.

265. (B) Temporarily elevating the priority of the lower-priority resource-holding task to match that of the higher-priority waiting task
The Priority Inheritance Protocol resolves priority inversion by temporarily elevating the execution priority of a lower-priority task holding a shared resource. When a higher-priority task requests the same resource, the holding task's priority is raised to match it, preventing preemption by medium-priority tasks and ensuring rapid resource release.

266. (B) Target ARM machine code executable on the device
A cross-compiler hosted on an x86 Windows PC targeting an ARM microcontroller compiles source files into target-specific ARM machine instructions. While the compilation tool runs on the host PC architecture, the generated output binary is incompatible with the host and must be transferred to the target device for execution.

Click Here to Buy book on Flipkart

204. (C) Register-Transfer Level
In hardware design and synthesis, RTL stands for Register-Transfer Level. This abstraction models a synchronous digital circuit by defining the flow of digital signals between hardware registers and the combinational logic operations performed on those signals, serving as the primary input for logic synthesis tools to generate physical netlists.

205. (D) Technology mapping
Technology mapping is the critical synthesis step that translates a generic gate-level representation of a design into a netlist composed of specific cells from a target semiconductor library. This process optimizes the logic structure to match the physical properties, timing constraints, and power characteristics of the selected manufacturing technology.

206. (C) C/C++ or SystemC algorithmic source
High-Level Synthesis tools compile algorithmic specifications written in high-level languages, such as C, C++, or SystemC, directly into hardware description language code. This compilation process automates the creation of register-transfer level designs, enabling engineers to model, simulate, and verify complex algorithms at a higher level of abstraction before physical synthesis.

207. (B) The execution times and resource utilization of software functions to identify bottlenecks
Profiling tools in hardware-software co-design analyze the execution characteristics of a software system. By measuring function execution times and resource utilization, these tools identify performance bottlenecks. This data guides developers in deciding which computationally heavy software modules should be migrated to custom hardware accelerators to optimize performance.

208. (D) Validate software and hardware model interaction concurrently
Hardware-software co-simulation enables developers to validate the functional interaction between software programs and hardware models simultaneously. By executing software on simulated processor models while simulating the surrounding digital hardware, this methodology detects integration errors and timing mismatches early in the design cycle, before physical prototypes are manufactured.

209. (A) Formal Verification
Formal verification uses rigorous mathematical algorithms to analyze a digital design against its formal specifications. Unlike simulation, which tests discrete vectors, this methodology evaluates all possible operational states to mathematically prove the absence of design defects or property violations, providing complete verification coverage for critical system components.

210. (A) Both A and R are true and R is the correct explanation of A.
Hardware emulation is significantly faster than software-based RTL simulation because it maps the digital design onto physical reconfigurable arrays, such as FPGAs. This allows the logic to execute concurrently in hardware rather than sequentially on a CPU, dramatically accelerating verification and making both statements true and logically consistent.

NODIA

211. (A) A software model running on a host machine that mimics the execution behavior of a target processor instruction set
An Instruction Set Simulator is a software tool running on a host computer that mimics the behavior of a target processor. It decodes and executes the target machine instructions, allowing developers to debug and analyze software applications before physical hardware is available, accelerating the overall embedded software development cycle.

212. (D) Ensure layout patterns meet foundry physical processing constraints
Design Rule Checking is a vital step in electronic design automation that verifies physical integrated circuit layouts. It checks the layout geometry against manufacturing rules provided by the semiconductor foundry, ensuring the design meets minimum spacing and width constraints, which prevents fabrication defects and guarantees manufacturing yield.

213. (B) A synthesizable behavioral RTL design in Verilog/VHDL
A Soft IP Core is delivered as a synthesizable, high-level behavioral description written in hardware description languages such as Verilog or VHDL. This format offers high flexibility, enabling designers to modify the design parameters and synthesize the logic for various target FPGA architectures or application-specific integrated circuit processes.

CHAPTER 08
Digital Image Processing

2019

1. The human visual system perceives brightness non-linearly. Which mathematical relationship best approximates the psychovisual perception of light intensity variations?
(A) Linear response to incident luminance
(B) Logarithmic response to light intensity
(C) Exponential response to simultaneous contrast
(D) Inverse-square response to source distance

2001

2. According to the Nyquist-Shannon sampling theorem, what is the minimum sampling frequency required to prevent aliasing in an image with a maximum spatial frequency of $f_{\max}$?
(A) Exactly $f_{\max}$
(B) Less than $2f_{\max}$
(C) Exactly $2f_{\max}$
(D) Greater than $2f_{\max}$

2021

3. In digital image processing, which distance measure between two pixels $p(x, y)$ and $q(s, t)$ is calculated as $D_8(p, q) = \max(|x - s|, |y - t|)$?
(A) Chessboard distance
(B) Euclidean distance
(C) City-block distance
(D) Mahalanobis distance

2002

4. Which spatial domain point operation expands the dynamic range of a specific narrow band of low-contrast gray levels in an image while leaving others unchanged?
(A) Log transformation
(B) Bit-plane slicing
(C) Contrast stretching
(D) Image negative

2013

5. Histogram equalization aims to produce an output image whose probability density function (PDF) of gray levels is mathematically close to which type of distribution?
(A) Uniform distribution
(B) Gaussian distribution
(C) Rayleigh distribution
(D) Exponential distribution

NODIA

2004

6. When utilizing image subtraction for mask mode radiography, what is the primary diagnostic purpose of the operation?
(A) To enhance the high-frequency edge details of the skeletal structure
(B) To suppress the random additive Gaussian noise introduced by the sensor
(C) To equalize the overall illumination levels across the entire image
(D) To isolate structural changes by removing static background anatomy

2003

7. Which of the following is an INCORRECT statement regarding spatial filters?
(A) A median filter is a non-linear spatial filter highly effective at removing impulse noise.
(B) A Laplacian filter directly yields a sharply enhanced image without adding the original.
(C) A mean filter is a linear spatial operator that blurs details while reducing random noise.
(D) The Sobel operator utilizes first-order derivative approximations to locate edge pixels.

2014

8. In frequency domain filtering, which lowpass filter exhibits no ringing artifacts in the spatial domain due to its smooth transition profile?
(A) Ideal lowpass filter
(B) Butterworth lowpass filter of order 10
(C) Gaussian lowpass filter
(D) Rectangular window filter

2003

9. Which discrete image transform uses basis functions consisting exclusively of alternating square waves with values of +1 and -1?
(A) Discrete Cosine Transform (DCT)
(B) Slant Transform
(C) Haar Transform
(D) Hadamard Transform

occur, allowing the system to handle multiple asynchronous inputs concurrently while meeting strict real-time deadline requirements.

224. (D) The present state of the inputs
In digital logic, a combinational circuit's output is determined solely by the current state of its inputs at any given instant. Because these circuits lack internal memory or storage elements like flip-flops, their outputs change in response to input variations, subject only to logic gate propagation delays.

225. (A) Cascaded flip-flop components sharing clock signals
A shift register is a synchronous sequential circuit composed of cascaded flip-flops that share a common clock signal. With each clock pulse, data shifts from one flip-flop stage to the next, enabling efficient serial-to-parallel or parallel-to-serial data conversion and temporary storage in digital systems.

226. (C) Combinational logic gates
The Arithmetic Logic Unit of a processor is implemented using combinational logic gates, such as adders, subtractors, and logical multiplexers. These components perform arithmetic and bitwise operations on input operands, producing results instantly without storing state, which is handled separately by registers in the processor.

227. (A) It boosts execution throughput by overlapping instruction phases
Instruction pipelining is a fundamental processor design technique that increases instruction execution throughput by overlapping different stages of multiple instructions. By partitioning execution into sequential stages, such as fetch, decode, and execute, the processor can work on different phases of multiple instructions simultaneously.

228. (D) A processor customized for specialized application class workload
An Application-Specific Instruction-set Processor represents a bridge between general-purpose processors and custom ASICs. It features a programmable instruction set customized for a specific class of applications, such as digital signal processing or network routing, combining hardware efficiency with software programmable flexibility.

229. (B) No shared clock line exists between transmitter and receiver units
UART communication is asynchronous because it does not rely on a shared clock signal between the transmitting and receiving devices. Instead, both nodes must agree on a predefined transmission speed or baud rate, and the receiver synchronizes its clock using start and stop bits embedded within the data stream.

230. (A) III, I, IV, II
Establishing a Bluetooth connection begins with inquiry, where devices scan the physical medium to discover other active nodes. This is followed by paging, which requests a direct connection. Once established, the nodes perform service discovery to configure the link, after which secure data transfer can proceed.

231. (D) The total count of physical signal state changes made each second
In serial communication, the baud rate defines the number of physical signal state transitions per second on the transmission line. While it is often equated with bits per second, they can differ if a single signal state represents more than one bit of data.

232. (A) RS-485 supports multi-drop networks using up to 32 transceivers
The RS-485 standard offers significant advantages over RS-232, supporting multi-drop networks with up to thirty-two transceivers on a single shared bus. Its differential signaling design provides superior noise immunity over long distances, allowing high-speed, reliable communication in harsh environments.

233. (B) A digital packet
In Universal Serial Bus architecture, all communications are initiated by the host controller using a highly structured packet-based format. These digital packets carry address, control, data, and error-checking information, ensuring organized and reliable data exchange between the host and multiple connected peripheral devices.

234. (B) Collision Detection
Ethernet networks utilize carrier sense multiple access with collision detection to coordinate shared medium access. Under CSMA/CD, devices monitor the network before transmitting, and if two nodes transmit simultaneously, they detect

Downloaded from www.pdf.tube

2010

19. When applying the Hough transform for line detection, a straight line in the xy-image plane is mapped to which geometric structure in the $r\theta$ -parameter space?
(A) A point
(B) A straight line
(C) A sinusoidal curve
(D) A parabolic curve

2014

20. Match the segmentation methods in List I with their characteristic definitions in List II.
List I: (Segmentation Methods)
P. Otsu's Method
Q. Region Growing
R. Watershed
S. Split and Merge
List II: (Definitions)
1. Groups sub-regions based on homogeneity predicates
2. Maximizes between-class variance for thresholding
3. Appends neighboring pixels to a set of seed points
4. Treats pixel values as topographic elevations
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-1, Q-4, R-3, S-2
(D) P-2, Q-1, R-4, S-3

2008

21. Which shape descriptor utilizes a sequence of direction numbers to represent the boundary of an object on a discrete grid?
(A) Freeman chain code
(B) Polygonal approximation
(C) Medial axis transform
(D) Spatial signature

2022

22. In the context of topological shape descriptors, the Euler number (E) of a region is mathematically defined by which relationship between the number of connected components (C) and the number of holes (H)?
(A) $E = C + H$
(B) $E = C \times H$
(C) $E = H - C$
(D) $E = C - H$

2005

23. Which type of data redundancy is caused by the fact that certain gray-level transitions are structurally highly probable due to local pixel correlations?
(A) Coding redundancy
(B) Spatial redundancy
(C) Psychovisual redundancy
(D) Chromatic redundancy

2023

24. Huffman coding achieves data compression by leveraging which principle of information theory?
(A) Discarding psychovisually imperceptible high-frequency coefficients
(B) Predicting pixel values based on their nearest neighbors
(C) Assigning shorter codes to more frequently occurring symbols
(D) Storing only the run lengths of consecutive identical symbols

NODIA

2008

25. Which fundamental digital image representation system typically assigns the origin $(0,0)$ to the top-left corner of the matrix?
(A) Standard Cartesian coordinate system
(B) Continuous polar coordinate system
(C) Three-dimensional spherical system
(D) Digital image coordinate system

2025

26. Which consequence inevitably arises if an image is sampled below the Nyquist rate?
(A) Spatial aliasing or Moiré patterns
(B) Ringing artifacts along edges
(C) Reduction in contrast dynamic range
(D) Introduction of additive Gaussian noise

2003

27. Identify the correct pair defining pixel adjacency.
(A) 4-adjacency: Diagonal neighbors only
(B) 8-adjacency: Horizontal, vertical, and diagonal neighbors
(C) m-adjacency: Eliminates 4-path ambiguities by adding more diagonal links
(D) D-adjacency: Horizontal and vertical neighbors only

2004

28. Gray-level slicing with a background-preserving piecewise linear transformation is best suited for which application?
(A) Producing a high-fidelity photographic negative of the input image
(B) Highlighting key gray levels while preserving overall context
(C) Compressing the dynamic range of a highly high-contrast image globally
(D) Separating all constituent bit planes of a digital image sequentially

(B) Eigenvalue decomposition
(C) Spline interpolation
(D) Wavelet theory

2004

106. The Singular Value Decomposition (SVD) of an $M \times N$ image matrix computationally yields a set of matrices. The diagonal matrix Σ contains the singular values arranged in what order?
(A) Descending order of magnitude
(B) Completely random spatial order
(C) Ascending order of statistical magnitude
(D) Alternating positive and negative signs

2002

107. By applying homomorphic filtering, one attempts to suppress the illumination component. This translates mathematically to filter out which region of the image spectrum?
(A) High frequencies
(B) Low frequencies
(C) The entire phase spectrum
(D) The diagonal directional frequencies

2024

108. The spatial noise model where pixels are randomly degraded by extremely low and extremely high artificial values is known as:
(A) Gaussian white noise
(B) Salt-and-Pepper noise
(C) Multiplicative speckle noise
(D) Exponential Erlang noise

2013

109. Which restoration technique explicitly requires an estimate of the degradation function $H(u, v)$ but fails catastrophically when $H(u, v)$ approaches zero?
(A) Direct Inverse filter
(B) Constrained Least Squares filter
(C) Wiener filter
(D) Minimum Mean Square Error filter

2014

110. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Bilinear interpolation produces smoother transformed images than nearest-neighbor interpolation.
Reason (R): Bilinear interpolation calculates pixel values based on a weighted average of the four surrounding discrete integer coordinates.
In light of the above statements, choose the correct answer from the options given below:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A)
(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2005

111. The RGB color model is mathematically represented as a geometric solid of what shape?
(A) Sphere
(B) Hexagon
(C) Cylinder
(D) Cube

2015

112. In color image processing, applying a Laplacian filter directly to the R, G, and B components independently will result in:
(A) Excellent edge sharpening without introducing any noticeable color artifacts
(B) Total saturation of the hue channel across all high-frequency areas
(C) Sharpening with localized color boundary shifts
(D) Complete conversion of the spatial image to a smooth pseudocolor gradient

2008

113. If an image is subjected to an Erosion operation followed immediately by a Dilation using the same structuring element, the process is called:
(A) Morphological Closing
(B) Morphological Opening
(C) Morphological Gradient
(D) Top-hat Transform

2005

114. The morphological boundary extraction algorithm relies fundamentally on calculating the difference between the original image and which morphological derivative?
(A) The Dilated image
(B) The Opened image
(C) The skeletonized image
(D) The Eroded image

2025

115. Which local processing technique relies on computing the gradient magnitude and direction to link edge pixels into meaningful boundaries?
(A) Local edge following
(B) The global Hough transform
(C) Otsu's adaptive thresholding
(D) Watershed segment transformation

Click Here to Buy book on Amazon

(A) Severe localized chromatic aberration artifacts
(B) Significant spatial domain ringing artifacts
(C) Unintentional contrast stretching effects
(D) Unmapped holes or overlapping pixels

2006

39. In the CMYK color model utilized for printing, what physical property necessitates the inclusion of the 'K' (black) component?
(A) Cyan, Magenta, and Yellow inks are chemically unable to absorb infrared spectrum light.
(B) Subtractive mixing of CMY inks yields a muddy brown instead of black.
(C) The K channel provides critical high-frequency edge detection and detail enhancement.
(D) The CMY components alone completely oversaturate the underlying printed paper medium.

2001

40. Consider the following statements regarding full-color image processing:
I. Color transformations can be applied to individual RGB planes independently.
II. Smoothing a full-color image alters the hue if spatial averaging is performed independently on RGB channels.
III. The HSI model isolates intensity, allowing processing without affecting color information.
IV. Pseudocolor processing can only be applied to binary images.
Which of the above statements are correct?
(A) I, II and IV
(B) II, III and IV
(C) I, II and III
(D) I and III

2024

41. Which sequence of basic morphological operations explicitly defines the Opening operation?
(A) Dilation followed by Erosion
(B) Dilation followed by Subtraction
(C) Hit Transform followed by Miss Transform
(D) Erosion followed by Dilation

2022

42. In morphological boundary extraction of a set A using structuring element B, which expression correctly defines the operation?
(A) $A - (A \ominus B)$
(B) $(A \oplus B) - A$
(C) $A \oplus B$
(D) $A \circ B$

2007

43. When using a second-derivative operator like the Laplacian for edge detection, an edge is specifically localized at which feature?
(A) The maximum absolute peak
(B) The zero-crossing point
(C) The minimum absolute trough
(D) The point of constant slope

2025

44. What defines a "global" threshold in image segmentation?
(A) A threshold calculated independently for every non-overlapping sub-image
(B) A single threshold value applied uniformly across the entire image
(C) A threshold that depends on the spatial coordinates of each pixel
(D) A threshold determined strictly by the phase angle of the Fourier spectrum

2017

45. Which image representation method reduces a 2D region into a 1D graph representing the locus of the centers of maximal inscribed circles?
(A) Medial axis transform (skeletonization)
(B) Boundary representation via spatial signatures
(C) Piecewise segment polygonal approximation
(D) One-dimensional run-length boundary encoding

NODIA

2016

46. Texture descriptors based on the Gray-Level Co-occurrence Matrix (GLCM) capture which type of information?
(A) The global probability distribution of individual pixel intensities
(B) The dominant spatial frequency components of the local image gradient
(C) The spatial relationship and frequencies of pixel pairs
(D) The topological connectivity of segmented binary components in space

2017

47. In image compression, Peak Signal-to-Noise Ratio (PSNR) is primarily used as a metric for which of the following?
(A) Statistical estimation of source information entropy values
(B) Verification of lossless compression ratio bounds

(C) Global measurement of spatial pixel redundancies
(D) Objective fidelity criteria for reconstructed quality

2016
48. LZW (Lempel-Ziv-Welch) coding is classified as which type of compression algorithm?
(A) Transform-based lossy source coding
(B) Predictive-based lossy differential coding
(C) Dictionary-based error-free coding
(D) Fractal-based block partition compression

2024
49. Electromagnetic radiation utilized in medical X-ray imaging occupies which end of the electromagnetic spectrum relative to visible light?
(A) Lower frequency, longer wavelength
(B) Higher frequency, shorter wavelength
(C) Lower frequency, shorter wavelength
(D) Higher frequency, longer wavelength

2024
50. Consider the following statements regarding image sampling and resolution:
I. Spatial resolution is determined by the number of quantization levels.
II. Gray-level resolution refers to the smallest discernible change in intensity.
III. Downsampling an image without a lowpass filter risks aliasing.
IV. The Nyquist criterion requires sampling at half the maximum frequency.
V. Interpolation can recover true spatial frequencies lost to aliasing.
Which of the above statements are INCORRECT?
(A) I, II and III
(B) II, III and IV
(C) I, IV and V
(D) II, IV and V

2015
51. Which pixel connectivity eliminates the ambiguity of multiple paths when tracing the boundary of a digital object?
(A) m-connectivity
(B) 4-connectivity
(C) 8-connectivity
(D) 16-connectivity

2014
52. Applying a power-law transformation with a gamma (γ) value strictly greater than 1 has what visual effect on an image?
(A) It expands the dark intensity pixels while compressing the bright pixels.
(B) It creates a binary high-contrast image.
(C) It compresses the dark pixels while expanding the bright pixels.
(D) It inverses the intensity spectrum.

2019
53. If a digital image contains primarily very bright pixels with low contrast, where will its histogram be heavily concentrated?
(A) At the higher end (near $L-1$)
(B) At the lower end (near 0)
(C) Centered uniformly around the mid-gray value
(D) Distributed equally across all gray levels

2022
54. Bit-plane slicing represents an 8-bit image using 8 separate binary planes. Which bit plane contains the majority of visually significant structural data?
(A) Bit plane 0 (Least Significant Bit)
(B) Bit plane 4
(C) All bit planes contribute equally to visual structure.
(D) Bit plane 7 (Most Significant Bit)

2006
55. Which first-order derivative operator utilizes two 3×3 convolutional masks emphasizing horizontal and vertical edges while applying a smoothing effect across the orthogonal axis?
(A) Roberts cross operator
(B) Sobel operator
(C) Prewitt operator
(D) Laplacian operator

2004
56. The computation of a 2D Discrete Fourier Transform generally exhibits a time complexity of $O(N^2 \log_2 N)$ using which algorithm?
(A) Standard direct matrix multiplication method
(B) Optimal Karhunen-Loève transform algorithm
(C) Fast Fourier Transform (FFT) algorithm
(D) Spatial convolution theorem

2017
57. Which characteristic makes the Discrete Cosine Transform (DCT) exceptionally suitable for block-based image compression standards like JPEG?
(A) It introduces highly severe block boundary discontinuities during reconstruction.
(B) It requires intensely complex floating-point

Downloaded from www.pdf.tube

arithmetic for its basis functions.
(C) It inherently performs completely lossless compression without any spatial degradation.
(D) It effectively minimizes implicit periodic boundary discontinuities.

2015
58. By ordering the singular values of an image matrix in decreasing magnitude and zeroing out the smallest values, SVD can be directly utilized for which process?
(A) Image data compression
(B) Morphological closing operations
(C) Exact lossless signal reconstruction
(D) Standard color space conversion

2019
59. In the illumination-reflectance model, which component is typically assumed to vary slowly and dictates the low-frequency content of the image?
(A) Reflectance
(B) Illumination
(C) Additive noise
(D) Transmittance

2009
60. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Salt-and-pepper noise is NOT effectively suppressed by a linear mean filter.
Reason (R): The mean filter averages all pixel values in the neighborhood, blurring the impulse spikes into the background rather than eliminating them.
In light of the above statements, choose the correct answer from the options given below:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A)
(B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A)
(C) (A) is true but (R) is false
(D) (A) is false but (R) is true

2012
61. Constrained Least Squares filtering improves upon standard Wiener filtering by explicitly incorporating which regularization element?
(A) A measure of smoothness via the Laplacian
(B) An assumption of purely Gaussian periodic noise distributions
(C) A complex non-linear threshold for impulse noise suppression
(D) The topological Euler number calculated from the degraded image

2008
62. Which affine transformation matrix operation relies on non-zero off-diagonal elements to slant the geometric coordinates of an image?
(A) Translation
(B) Scaling
(C) Shearing
(D) Rotation

2024
63. Which fundamental property of color defines the purity of the color, distinguishing how much white light is mixed with the pure hue?
(A) Brightness
(B) Intensity
(C) Chrominance
(D) Saturation

2001
64. When performing spatial color smoothing using a mean filter, why is it theoretically preferable to apply the filter to the intensity channel of the HSI model rather than the RGB channels?
(A) The HSI mathematical model is completely unable to represent high-frequency spatial noise.
(B) Standard RGB color components are fundamentally independent of local spatial frequency properties.
(C) It reduces computing overhead without inducing false colors.
(D) It guarantees absolute and perfect preservation of all high-frequency structural edges.

NODIA

2005
65. The morphological Hit-or-Miss transform requires two structuring elements. What is the fundamental requirement for these two elements?
(A) They must be completely geometrically identical in size.
(B) They must be disjoint without overlapping active pixels.
(C) They must entirely encompass the continuous image domain.
(D) One must be precisely twice the spatial size of the other.

2007
66. Morphological thickening is conceptually analogous to which other morphological algorithm applied to the background of a set?
(A) Erosion
(B) Opening

(C) Skeletonization
(D) Thinning

2008

67. Gradient-based edge detection techniques are highly susceptible to which image degradation?
(A) Additive random noise
(B) Global uniform illumination shifts
(C) Linear geometric translation
(D) Chromatic aberration

2004

68. Region growing algorithms rely critically on the selection of which initial parameters?
(A) Globally optimal threshold intensity limits
(B) Invariant shape boundaries Fourier descriptors
(C) Seed points and homogeneity criteria
(D) Arbitrary structuring element spatial geometry

2021

69. When encoding an object's boundary, what is a primary limitation of basic 8-directional Freeman chain codes that must be addressed for robust recognition?
(A) They depend heavily on starting points and rotation.
(B) They require computationally heavy floating-point arithmetic.
(C) They are mathematically unable to represent diagonal contours.
(D) They automatically perform thinning to skeletonize the boundary.

2024

70. Match the boundary and regional descriptors in List I with their mathematical applications in List II.
List I: (Descriptors)
P. Fourier Descriptors
Q. Shape Numbers
R. Co-occurrence Matrices
S. Hu's Invariant Moments
List II: (Applications)
1. Represents texture via spatial dependencies
2. Provides scale, translation, and rotation invariance
3. Reduces 2D boundary to 1D complex sequence
4. Uses first difference of chain codes
(A) P-1, Q-4, R-2, S-3
(B) P-3, Q-1, R-4, S-2
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-1, S-4

2008

71. Psychovisual redundancy is fundamentally exploited by which standard class of image compression techniques?
(A) Error-free variable length coding
(B) Lossy compression schemes
(C) Run-length encoding
(D) LZW dictionary coding

2022

72. In the JPEG compression standard, the spatial image data is initially partitioned into blocks of what specific dimension before applying the DCT?
(A) 4×4
(B) 8×8
(C) 16×16
(D) 32×32

2010

73. Which feature of the human visual system explains the phenomenon of "Mach bands," where boundaries between uniform bands of differing intensities appear artificially enhanced?
(A) Non-uniform rod-cone cellular distribution
(B) Localized blind spot optical interference
(C) Dynamic retinal chromatic adaptation processes
(D) Lateral inhibition within the retina

2012

74. Assuming an image is sampled at 600 dots per inch (dpi), what is the exact spatial distance between adjacent pixels in millimeters? (Assume 1 inch = 25.4 mm)
(A) 0.042 mm
(B) 0.084 mm
(C) 0.254 mm
(D) 4.23 mm

2003

75. Identify the INCORRECT statement regarding distance measures in a discrete pixel grid.
(A) Euclidean distance maps directly to circular concentric boundaries.
(B) The City-block distance between (x, y) and $(x+1, y+1)$ is 1.
(C) City-block (D_4) distance forms a diamond-shaped contour.
(D) Chessboard (D_8) distance forms a square-shaped contour.

2024

76. In contrast stretching using a piecewise linear transformation, if the transformation function passes through the coordinates $(0,0)$, (r_1, s_1),

Click Here to Buy book on Flipkart

(r_2, s_2), and $(L-1, L-1)$, what specific condition creates a binary thresholding effect?
(A) $r_1 = 0$ and $r_2 = L-1$ with constant slope
(B) $r_1 = r_2$ and $s_1 = 0, s_2 = L-1$
(C) $s_1 = s_2$ for any arbitrary values of r
(D) $r_1 = s_1$ and $r_2 = s_2$ globally

2017

77. Local histogram equalization is typically implemented by computing the histogram within a small moving window and updating which pixel's intensity?
(A) Only the center pixel of the window
(B) All pixels within the window simultaneously
(C) The four corner pixels of the window
(D) The boundary pixels of the window

2014

78. Which logical operation is fundamentally used to implement region-of-interest (ROI) masking in binary and grayscale images?
(A) Logical OR
(B) Logical XOR
(C) Logical AND
(D) Logical NOT

2007

79. When using the unsharp masking technique for image sharpening, the unsharp mask is mathematically generated by which specific process?
(A) Adding the high-frequency Laplacian directly to the original image
(B) Multiplying the input image spectrum by a sharpening highpass filter
(C) Applying a non-linear median filter to the spatial image gradient
(D) Subtracting a blurred version of the image from the original

2001

80. Consider the following statements regarding the 2D Discrete Fourier Transform:
I. The DFT spectrum exhibits conjugate symmetry for real-valued images.
II. Multiplication in the spatial domain corresponds to convolution in the frequency domain.
III. High-frequency components correspond to smooth transitions in gray levels.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) I

2003

81. The Sine Transform is a mathematical derivative of the Fourier Transform uniquely suited for signals possessing which type of symmetry?
(A) Even symmetry
(B) Odd symmetry
(C) Half-wave symmetry
(D) Spherical symmetry

2002

82. Which advanced statistical transform calculates eigenvectors from the image covariance matrix to align its basis functions perfectly with the axes of maximum variance?
(A) Singular Value Decomposition
(B) Haar Transform
(C) Discrete Cosine Transform
(D) Karhunen-Loève Transform

2025

83. In homomorphic filtering, increasing the high-frequency components while suppressing the low-frequency components simultaneously achieves which two visual enhancements?
(A) Dynamic range compression and contrast enhancement
(B) High-frequency blur reduction and random noise removal
(C) Spatial edge linking and adaptive region splitting
(D) Geometric image registration and aliasing artifact removal

2017

84. Which environmental or systemic factor is the most common mathematical cause of periodic noise in digital images?
(A) Low-light level photon variations within the imaging sensor
(B) Global overexposure of the camera CCD array during acquisition
(C) Electrical interference during capture
(D) Multi-level quantization errors occurring during digitization

2023

85. The Geometric Mean filter is a highly robust restoration filter. Under what specific condition does the Geometric Mean filter functionally reduce to the standard Inverse filter?
(A) When the noise variance approaches zero
(B) When the blurring function is unknown
(C) When the image is subjected to uniform Gaussian noise
(D) When the phase spectrum is ignored

Downloaded from www.pdf.tube

2009

86. Which spatial transformation must be represented using homogeneous coordinates to be expressed as a linear matrix multiplication?
(A) Scaling transformations
(B) Rotation transformations
(C) Shearing transformations
(D) Translation

2021

87. In the YCbCr color space commonly used in digital video, what do the Cb and Cr components specifically represent?
(A) Subtractive Cyan and Crimson chromaticity hue angles
(B) Blue-difference and Red-difference components
(C) Luminance contrast brightness and color reflectance values
(D) Cyan-black and Crimson-red subtractive reflectance values

2017

88. When performing histogram equalization on a full-color RGB image, doing so independently on the R, G, and B channels will inevitably result in which undesirable artifact?
(A) Severe global loss of structural spatial resolution
(B) Highly visible block-edge spatial discontinuities
(C) Unpredictable and erroneous color hue shifts
(D) Total immediate conversion of the image to grayscale

2012

89. A morphological Closing operation is analytically defined as:
(A) Erosion followed by Dilation
(B) Erosion followed by Intersection
(C) Dilation followed by Union
(D) Dilation followed by Erosion

2005

90. Consider the following statements regarding advanced morphological algorithms:
I. Thinning iteratively removes boundary pixels while preserving connectedness.
II. The morphological gradient calculates the difference between dilation and erosion.
III. Region filling strictly utilizes the Erosion operator to flood internal areas.
IV. A morphological skeleton can exactly reconstruct the original shape without prior structural knowledge.
Which of the above statements are INCORRECT?
(A) I and II
(B) II and III
(C) I, II and IV
(D) III and IV

2023

91. The Hough transform maps collinear points in the spatial domain to what specific intersection structure in the parameter space?
(A) A distinct cluster of parallel straight line trajectories
(B) An intersecting point of sinusoidal curves
(C) A continuous straight orthogonal line segment in space
(D) A highly uniform and symmetric circular boundary shape

2025

92. Region splitting and merging segmentation frameworks generally structure the image data using which type of hierarchical tree representation?
(A) Binary search tree
(B) Quadtree
(C) AVL tree
(D) Minimum spanning tree

2013

93. When approximating a digital boundary using a minimum perimeter polygon technique, the boundary is bounded by two concentric shapes known as:
(A) Cellular complexes
(B) Inner and outer ellipses
(C) Convex and concave hulls
(D) Shrinking and expanding elastic bands

NODIA

2015

94. The statistical moment-based descriptor $m_{pq} = \sum_x \sum_y x^p y^q f(x, y)$ provides the centroid of a region when evaluated at which specific order?
(A) The zeroth-order moment where $p = 0, q = 0$
(B) The diagonal first-order moment where $p = 1, q = 1$
(C) Ratios $\frac{m_{10}}{m_{00}}$ and $\frac{m_{01}}{m_{00}}$
(D) The second-order coordinate moment where $p = 2, q = 2$

2010

95. In predictive image coding, which mathematical element is actually transmitted or stored to achieve compression?
(A) The exact raw intensity value of each individual pixel
(B) The localized Fourier transform coefficients

of the pixel block
(C) The statistical mode value computed over the local neighborhood
(D) The difference of pixel and prediction

2009

96. Fractal image compression exploits which specific geometric property inherent in many natural images to achieve high compression ratios?
(A) Spectral even symmetry characteristics
(B) Strict topological boundary connectedness
(C) Self-similarity at varying scales
(D) Isometric coordinate translation variance

2023

97. The concept of "brightness adaptation" in the human visual system refers to the eye's ability to do what?
(A) Discriminate extremely fine structural details at very long spatial distances
(B) Perceive huge dynamic ranges by shifting its sensitivity curve
(C) Focus simultaneously on multi-colored objects without chromatic aberration
(D) Resolve high-frequency spatial aliasing patterns in textured surfaces

2001

98. When an analog image is quantized into 256 discrete levels, how many bits per pixel are mathematically required to store the uncompressed image?
(A) 4 bits
(B) 8 bits
(C) 16 bits
(D) 256 bits

2009

99. If a pixel p has coordinates (x,y), the set of coordinates $\{(x+1,y),(x-1,y),(x,y+1),(x,y-1)\}$ represents which structural neighborhood?
(A) The 4-neighborhood $N_4(p)$
(B) The diagonal neighborhood $N_D(p)$
(C) The 8-neighborhood $N_8(p)$
(D) The Euclidean neighborhood

2017

100. Consider the following statements regarding point operations:
I. Point operations alter pixel values based solely on their original intensity, ignoring neighbor pixels.
II. A negative image transformation is defined as $s = L-1-r$.
III. Power-law transformations cannot be used for CRT monitor gamma correction.
IV. Gray-level slicing is exclusively a frequency domain operation.
V. Contrast stretching improves the dynamic range of pixel distributions.
Which of the above statements are correct?
(A) I, II and V
(B) I, II, III and V
(C) II, IV and V
(D) I, III and IV

2022

101. Histogram equalization functions optimally for images possessing what type of original histogram profile?
(A) A narrow, highly concentrated peak at any intensity level
(B) A perfectly flat, uniform distribution
(C) A bimodal distribution tightly clustered at opposite intensity extremes
(D) A pure single-value delta function

2018

102. Which primary arithmetic operation is explicitly used in the technique of image averaging to reduce random sensor noise?
(A) Subtraction
(B) Multiplication
(C) Division
(D) Addition

2009

103. What is the defining characteristic of a Laplacian spatial filter mask?
(A) The sum of all its coefficients must equal 1.
(B) The sum of all its coefficients must equal 0.
(C) It must contain only positive fractional weights.
(D) It must be exclusively a 2×2 asymmetric matrix.

2019

104. Which frequency domain filter type completely cuts off all frequencies beyond a specified radius D_0, leading to pronounced ringing in the spatial domain?
(A) Gaussian lowpass filter
(B) Butterworth lowpass filter
(C) Ideal lowpass filter
(D) Trapezoidal lowpass filter

2009

105. In the context of discrete transforms, the Haar transform utilizes basis functions derived from which advanced mathematical concept?
(A) Spherical harmonics

Click Here to Buy book on Amazon

2012

29. Histogram matching (specification) requires the calculation of which mathematical property of the original image histogram before mapping it to the target?
(A) Cumulative Distribution Function
(B) Fast Fourier Transform algorithm
(C) Two-dimensional gradient magnitude
(D) Singular Value Decomposition matrix

2018

30. Consider the following statements regarding image averaging:
I. Image averaging significantly improves the signal-to-noise ratio.
II. It is highly effective for reducing multiplicative periodic noise.
III. It assumes that the noise is uncorrelated and has a zero mean.
Which of the above statements are correct?
(A) I and II
(B) II and III
(C) I and III
(D) I, II, and III

2015

31. What is the fundamental difference between linear and non-linear spatial filters?
(A) Linear filters alter spatial image dimensions dynamically, whereas non-linear filters preserve original sizes.
(B) Linear filters can only detect horizontal edges, whereas non-linear detect omnidirectional edges.
(C) Linear filters can operate in both spatial and frequency domains, while non-linear filters are strictly spatial.
(D) Linear filters compute weighted sums of pixels; non-linear filters use pixel ranking or logic.

2013

32. In the context of 2D Discrete Fourier Transforms, the zero-frequency (DC) term corresponds to which spatial domain characteristic?
(A) The absolute highest contrast edge present in the image
(B) The overall standard deviation of all pixel intensities
(C) The average gray-level intensity of the entire image
(D) The estimated high-frequency background noise variance

2002

33. Which discrete unitary transform provides energy compaction nearly equivalent to the optimal KLT, making it the standard for JPEG compression?
(A) Discrete Haar Transform
(B) Discrete Cosine Transform (DCT)
(C) Discrete Sine Transform
(D) Discrete Hadamard Transform

2012

34. Singular Value Decomposition (SVD) represents an image matrix A as the product $U\Sigma V^T$. What structural property do the matrices U and V possess?
(A) They are singular and non-invertible.
(B) They are purely diagonal matrices.
(C) They contain only binary values.
(D) They are orthogonal matrices.

2002

35. Which best describes the illumination-reflectance model used in homomorphic filtering?
(A) $f(x,y) = i(x,y) \times r(x,y)$
(B) $f(x,y) = i(x,y) + r(x,y)$
(C) $f(x,y) = i(x,y) \div r(x,y)$
(D) $f(x,y) = i(x,y) - r(x,y)$

NODIA

2014

36. An Erlang (Gamma) probability density function is primarily used to model which type of degradation in digital images?
(A) High-frequency periodic or electromagnetic interference
(B) Uniform probability distribution of pixel quantization errors
(C) Random noise associated with laser and radar imaging
(D) Missing data packets during high-speed image transmission

2008

37. Which filtering technique minimizes the mean square error between the estimated image and the true image, given knowledge of both the degradation function and noise variance?
(A) Wiener filtering
(B) Inverse filtering
(C) Constrained Least Squares filtering
(D) Median filtering

2008

38. When applying an affine transformation for image rotation, which defect often occurs if forward mapping is used instead of inverse mapping?

2003

116. Otsu's thresholding method mathematically determines the optimal global threshold by maximizing which specific statistical measure?
(A) Within-class variance
(B) Information entropy
(C) Between-class variance
(D) Geometric mean of the histogram

2025

117. When representing an object using its "signature," the 2D boundary is mapped into a 1D function representing:
(A) Centroid-to-boundary distance versus angle
(B) The sequential order of local spatial gradient magnitudes
(C) The cumulative mathematical sum of boundary pixel intensities
(D) The computed Fourier phase coefficients of the outer contour

2012

118. Which topological descriptor characterizes an object based strictly on its invariant structural properties under "rubber-sheet" deformations?
(A) Fourier descriptors
(B) Bounding box aspect ratio
(C) Area-to-perimeter squared ratio
(D) Euler number

2024

119. A coding scheme that assigns fixed-length codes to every possible symbol, regardless of the symbol's probability of occurrence, suffers primarily from which type of redundancy?
(A) Spatial redundancy
(B) Coding redundancy
(C) Psychovisual redundancy
(D) Temporal redundancy

2013

120. Match the compression techniques in List I with their characteristic mechanisms in List II.
List I: (Compression Techniques)
P. Huffman Coding
Q. Run-Length Encoding
R. DCT-based Coding
S. Predictive Coding
List II: (Mechanisms)
1. Compresses consecutive identical symbols into pairs
2. Encodes the error between actual and estimated pixels
3. Uses variable-length codes based on symbol probability
4. Discards high-frequency spectral coefficients
(A) P-3, Q-1, R-4, S-2
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-2, R-4, S-1
(D) P-2, Q-1, R-3, S-4

2003

121. The term "spatial resolution" is most accurately defined as:
(A) The total number of bits allocated to represent each pixel's distinct color channel
(B) The absolute smallest intensity change detectable by the sensor or human eye
(C) The physical size and aspect ratio of the active digital display monitor
(D) The level of fine detail expressed in line pairs per unit distance

2015

122. Under which mathematical condition does the aliasing phenomenon fundamentally alter an image during digitization?
(A) When sampling frequency is less than twice the highest spatial frequency
(B) When sampling frequency is greater than twice the highest spatial frequency
(C) When the quantization levels are insufficient to cover the dynamic range
(D) When the illumination field is highly non-uniform

2006

123. Which distance metric is strictly invariant to arbitrary angular rotation of the coordinate system?
(A) City-block distance
(B) Euclidean distance
(C) Chessboard distance
(D) Manhattan distance

2016

124. Logarithmic intensity transformations are specifically applied in image processing to achieve which visual objective?
(A) Stretching the spatial contrast of extremely bright foreground pixels
(B) Compressing dynamic ranges with immense brightness changes
(C) Inverting constituent gray levels to create a high-contrast negative
(D) Mathematically transforming spatial pixels into the frequency domain

2002

125. The mathematical derivation of continuous histogram equalization uses which fundamental theorem of probability?

Downloaded from www.pdf.tube

channel color data.
(C) They are sensitive to noise and seed point placement.
(D) They require mapping spatial data to the frequency domain.

2012
165. When analyzing boundaries, a polygonal approximation aims to achieve what specific goal?
(A) Minimizing line segments while maintaining boundary shape
(B) Increasing spatial resolution of the coordinate structure
(C) Smoothing the contour representation into a perfect ellipse
(D) Transforming the boundary sequence into a Fourier series

2009
166. Which boundary descriptor provides scale, translation, and rotation invariance by expanding the 1D complex boundary signal into an orthogonal series?
(A) Freeman chain codes
(B) Euler numbers
(C) Co-occurrence matrices
(D) Fourier descriptors

2022
167. In information theory, the absolute theoretical minimum average number of bits required to code each symbol based on their probabilities is known as:
(A) The Shannon limit
(B) The source entropy
(C) The Nyquist rate
(D) The Huffman boundary

2019
168. Which error-free coding algorithm constructs a dictionary dynamically during the encoding process without needing to transmit the dictionary to the decoder?
(A) Huffman Coding
(B) Arithmetic Coding
(C) LZW Coding
(D) Run-Length Encoding

2015
169. What biological mechanism is responsible for the human eye's perception of color under high-illumination (photopic) conditions?
(A) Rods
(B) The optic disc
(C) The blind spot
(D) Cones

2004
170. Match the digital image concepts in List I with their standard definitions in List II.
List I: (Concepts)
P. Sampling
Q. Quantization
R. Spatial Resolution
S. Aliasing
List II: (Definitions)
1. Digitizing the spatial coordinate values
2. Distortion caused by under-sampling high frequencies
3. Smallest discernible structural detail
4. Digitizing the continuous amplitude values
(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-1, R-3, S-2
(C) P-1, Q-3, R-4, S-2
(D) P-2, Q-4, R-1, S-3

2023
171. Which metric mathematically quantifies the length of the shortest 8-connected path between two pixels without traversing the background?
(A) Euclidean distance
(B) Geodesic distance
(C) Topological distance
(D) Mahalanobis distance

2013
172. A specific piecewise-linear intensity transformation maps all gray levels below a threshold T to 0 and all levels above T to 255. What is this operation called?
(A) Contrast stretching
(B) Thresholding
(C) Gray-level slicing
(D) Bit-plane slicing

2024
173. If an image is completely dark, possessing gray levels only between 0 and 15 (on a 0-255 scale), applying histogram equalization will result in:
(A) Enhanced contrast with high quantization noise
(B) A perfectly balanced and naturally illuminated image
(C) A uniform dark image with zero intensity variance
(D) A uniform light image with maximum intensity variance

NODIA

(A) Forward mapping only
(B) Direct matrix rotation without subpixel calculations
(C) Chain coding
(D) Inverse mapping and interpolation

2021

135. The CMY color model is based on subtractive color mixing. What color is perceived when Cyan, Magenta, and Yellow pigments are mixed at full maximum intensity?
(A) Pure White
(B) Pure Black
(C) Neutral Gray
(D) Pure Green

2021

136. Which color coordinate system is primarily used in compression standards like JPEG to decouple luminance from chrominance?
(A) RGB
(B) CMYK
(C) YCbCr
(D) HSI

2023

137. Which mathematical operation fundamentally defines the morphological Hit-or-Miss transform for detecting specific shapes in a binary image A?
(A) $(A \oplus B_1) \cup (A^c \oplus B_2)$
(B) $A \circ B$
(C) $A \cdot B$
(D) $(A \ominus B_1) \cap (A^c \ominus B_2)$

2011

138. The Morphological Gradient of a grayscale image is commonly computed to highlight which specific features?
(A) Sharp intensity transitions
(B) Homogeneous regional minima
(C) Uniform illumination zones
(D) Random high-frequency noise

2014

139. In the detection of isolated points using a 3×3 spatial mask, what must be the value of the center coefficient if all 8 surrounding coefficients are -1?
(A) 0
(B) 1
(C) 8
(D) 9

2022

140. Consider the following statements concerning thresholding:
I. Global thresholding uses a single constant value for the entire image.
II. Local thresholding calculates different thresholds based on neighborhood statistics.
III. Otsu's method requires explicit prior knowledge of the target object's shape.
IV. Adaptive thresholding is highly effective for images with non-uniform illumination.
Which of the above statements is/are INCORRECT?
(A) I and II
(B) III
(C) I, II and IV
(D) IV

2021

141. The Freeman chain code uses directional numbers to trace a boundary. If the boundary is traced clockwise, what mathematical property of the code makes it rotationally invariant?
(A) Utilizing the first difference of the chain code
(B) Subtracting the mean value from the code sequence
(C) Converting the codes to Euclidean distances
(D) Reversing the sequence order

2016

142. Shape numbers are utilized to categorize closed boundaries. What specifically dictates the "order" of a shape number?
(A) The sum of directional values in the code
(B) The geometric area enclosed by the boundary
(C) The chain code representation length
(D) The number of vertices in the polygon

2009

143. Mean Square Error (MSE) and Peak Signal-to-Noise Ratio (PSNR) evaluate which aspect of an image compression algorithm?
(A) The theoretical limit of compression
(B) The ratio of original to compressed size
(C) The computational execution time of the encoder
(D) The fidelity of the reconstructed image

2003

144. Which standard image compression method partitions images into blocks and uses contractive affine transformations of image parts to reconstruct the scene via Iterated Function Systems?
(A) JPEG-2000

Click Here to Buy book on Flipkart

(D) Yellow

2017

184. When applying independent histogram equalization to the R, G, and B color channels, the structural integrity of the image often degrades because:
(A) Equalization fails when applied to standard 8-bit channels.
(B) The physical spatial resolution is forcibly halved in each step.
(C) The relative RGB ratios are changed, distorting the hue.
(D) The transformation performs as an aggressive lowpass spatial filter.

2007

185. A binary image contains several overlapping circular objects. Which morphological algorithm is best suited to separate them?
(A) Spatial binary dilation
(B) Hit-or-Miss shape transform
(C) Boundary extraction via morphological gradient
(D) Watershed on the distance transform

2004

186. Which morphological operation effectively smooths the contours of an object, breaks narrow isthmuses, and eliminates thin protrusions?
(A) Opening
(B) Closing
(C) Thickening
(D) Boundary Extraction

2017

187. What is the fundamental principle driving the Canny edge detector's superiority over simple gradient operators?
(A) It relies on a single optimized global threshold to isolate active edge points.
(B) It uses smoothing, non-maximum suppression, and hysteresis thresholding.
(C) It performs multi-scale highpass filtering strictly within the frequency domain.
(D) It ignores high-frequency noise spikes by using adaptive spatial convolution.

2014

188. In region splitting and merging, the splitting phase recursively divides a region into four quadrants until which specific condition is met?
(A) Every sub-region is reduced to a single individual pixel element.
(B) The homogeneity predicate $P(R_i)$ is TRUE for that quadrant.
(C) The Fourier transform of the quadrant becomes perfectly uniform.
(D) The statistical variance exceeds a predefined global threshold.

2002

189. Which shape representation technique analyzes an object's boundary by calculating the distances from the boundary points to the object's centroid as a continuous 1D function?
(A) Spatial Signatures
(B) Polygonal Approximation
(C) Freeman Chain Codes
(D) Topological Skeletons

2010

190. Consider the following steps involved in the standard JPEG image compression pipeline:
I. Discrete Cosine Transform (DCT)
II. Huffman Coding (Entropy Coding)
III. Image division into 8×8 blocks
IV. Quantization of DCT coefficients
What is the correct sequential order of these steps?
(A) I, III, II, IV
(B) III, IV, I, II
(C) III, I, IV, II
(D) I, II, III, IV

2024

191. Information theory defines entropy as $H = -\sum p(z_k) \log_2 p(z_k)$. What does H mathematically represent for an image?
(A) The total uncompressed physical file memory size in megabytes.
(B) The highest possible spatial frequency coordinate value present.
(C) The dynamic ratio between maximum peak signal and background noise.
(D) The minimum bits per pixel needed for lossless representation.

NODIA

2013

192. Which international video compression standard heavily relies on motion compensation to eliminate temporal redundancy between adjacent frames?
(A) JPEG
(B) TIFF
(C) MPEG
(D) LZW

2007

193. The shift in peak spectral sensitivity of the human eye toward shorter wavelengths during

2005

154. Karhunen-Loève Transform (KLT) requires the calculation of which structural matrix representing the dataset's statistical variation?
(A) Covariance matrix
(B) Jacobian matrix
(C) Hessian matrix
(D) Laplacian matrix

2024

155. Which visual artifact is fundamentally reduced by utilizing dynamic range compression via homomorphic filtering?
(A) High-frequency impulse and salt-and-pepper noise
(B) Uneven contrast from illumination gradients
(C) Periodic spatial Moiré interference patterns
(D) Structural distortion from chromatic subsampling

2002

156. Which probability density function best models the noise generated by a badly calibrated sensor where certain pixels are completely unreactive (black)?
(A) Gaussian PDF
(B) Impulse PDF
(C) Rayleigh PDF
(D) Uniform PDF

2003

157. The Wiener filter incorporates the noise power spectrum and the image power spectrum. If the noise variance is explicitly zero, the Wiener filter equation mathematically reduces to:
(A) The Inverse filter
(B) The Constrained Least Squares filter
(C) The Mean filter
(D) The Ideal lowpass filter

2004

158. In the context of geometric transformations, affine mapping involves translation, scaling, and rotation. Which matrix dimension is used to represent 2D affine transformations using homogeneous coordinates?
(A) 1×3
(B) 2×2
(C) 3×3
(D) 4×4

2022

159. When capturing color, the three primary colors of light (additive primaries) are:
(A) Red, Yellow, Blue
(B) Cyan, Magenta, Yellow
(C) Hue, Saturation, Intensity
(D) Red, Green, Blue

2013

160. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Pseudocolor processing can dramatically increase human interpretability of grayscale medical images.
Reason (R): The human eye can discern thousands of distinct color shades and intensities, but only a few dozen shades of gray.
Based on the above statements, choose the correct option:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

NODIA

2003

161. Which advanced morphological algorithm is essentially defined as the intersection of an object with its translated counterparts to determine the object's core structural geometry?
(A) Hit-or-Miss Transform
(B) Erosion
(C) Region Filling
(D) Morphological Reconstruction

2007

162. The morphological "bottom-hat" transform is computed by subtracting the original image from which morphologically processed version of itself?
(A) The Opened image
(B) The Dilated image
(C) The Eroded image
(D) The Closed image

2019

163. The watershed segmentation algorithm conceptually treats gray-level intensities as:
(A) Topographic surface elevations
(B) Probabilistic likelihoods of edge existence
(C) Frequency magnitudes in the Fourier domain
(D) Temperature gradients across the sensor

2013

164. What is the fundamental disadvantage of standard region growing algorithms?
(A) They frequently produce fragmented and disjoint regions.
(B) They are incapable of processing multi-

(B) Vector Quantization
(C) Fractal Image Compression
(D) Lempel-Ziv-Welch (LZW) Coding

2008

145. What happens to the visual appearance of a digital image if the spatial resolution (dimensions in pixels) is drastically reduced while keeping the display size constant?
(A) Overall image contrast is inverted
(B) Blocky pixelation artifacts appear
(C) Random high-frequency noise increases
(D) The active color channels are lost

2017

146. Which consequence best characterizes an insufficient number of gray-level quantization bits in a digital image?
(A) Moiré patterns
(B) Geometric distortion
(C) Chromatic aberration
(D) False contouring

2025

147. If two pixels p and q share a common corner but do not share an edge, they are considered to be:
(A) Diagonally adjacent
(B) 4-adjacent
(C) Non-adjacent in an 8-neighborhood
(D) Continuously connected

2022

148. Which spatial point operation is primarily used to reverse the intensity values of an image, such as creating a negative of a medical scan to improve feature visibility?
(A) Contrast stretching
(B) Gamma correction
(C) Image negative
(D) Gray-level slicing

2019

149. The process of histogram matching is considered an extension of histogram equalization. What distinguishes matching from standard equalization?
(A) It maps the input histogram to a specified target distribution.
(B) It maps the input histogram to a uniform distribution only.
(C) It maps the input histogram strictly to a Gaussian distribution.
(D) It requires transforming the input image to the frequency domain.

2016

150. Consider the following statements concerning arithmetic operations on images:
I. Image addition is commonly used to superimpose a watermark.
II. Averaging noisy images requires the noise to be uncorrelated.
III. Image subtraction requires prior histogram equalization to function.
IV. Bit-plane slicing is a form of image division.
V. Multiplication can be used to apply binary masking.
Which of the above statements are correct?
(A) II, III, IV and V
(B) I, III and IV
(C) I, II, III and V
(D) I, II and V

2025

151. Which statement correctly identifies a distinct disadvantage of utilizing a median filter over a mean filter?
(A) It introduces severe blurring on high-contrast edges.
(B) It has higher computational complexity due to sorting.
(C) It fails to eliminate high-frequency periodic noise patterns.
(D) It alters the physical spatial boundary of the image.

2012

152. When applying a Gaussian lowpass filter in the frequency domain, what is the mathematical shape of its inverse Fourier transform in the spatial domain?
(A) A sinc function
(B) A step function
(C) A Gaussian function
(D) An impulse function

2019

153. The Discrete Cosine Transform (DCT) avoids the generation of artificial high-frequency edge artifacts at block boundaries by simulating what condition?
(A) Assuming the image is infinitely padded with zero values
(B) Applying a highpass spatial filter before transformation
(C) Computing the coefficients over circular local windows
(D) Mirroring boundaries to enforce even symmetry

Downloaded from www.pdf.tube

2006

174. Which logical operation is mathematically equivalent to computing the set intersection of two binary images?
(A) OR
(B) XOR
(C) AND
(D) NOT

2004

175. The directional gradient of an image can be approximated using the Sobel operator. How many convolution masks are strictly necessary to compute the full gradient magnitude?
(A) 1
(B) 2
(C) 4
(D) 8

2025

176. Which fundamental theorem states that multiplying an image by a complex exponential shifts the origin of its Discrete Fourier Transform?
(A) Convolution theorem
(B) Nyquist theorem
(C) Translation theorem
(D) Separability theorem

2011

177. The Hadamard transform utilizes basis vectors composed entirely of +1 and -1. This property provides which distinct computational advantage?
(A) It eliminates the need for any arithmetic accumulation or normalization.
(B) It avoids multiplications by using only additions and subtractions.
(C) It calculates the principal singular vectors without computing covariance.
(D) It preserves structural rotation invariance in high-dimensional space.

2019

178. What specific condition dictates that the Karhunen-Loève Transform (KLT) cannot be universally implemented via a fast algorithm (like the FFT)?
(A) Its transform kernel requires scaling with complex imaginary exponents.
(B) It is constrained to process strictly one-dimensional signal sequences.
(C) It requires analytical integration rather than discrete summation steps.
(D) Its basis vectors depend on the image's covariance matrix.

2016

179. Homomorphic filtering applies a linear filter to log-transformed image data. To enhance contrast, how should the high-frequency and low-frequency gains (γ_H and γ_L) be set relative to 1?
(A) $\gamma_H > 1$ and $\gamma_L < 1$
(B) $\gamma_H < 1$ and $\gamma_L > 1$
(C) Both must be exactly 1
(D) $\gamma_H = 0$ and $\gamma_L = 0$

2008

180. Select the correct sequence of steps involved in standard frequency domain filtering.
(A) Fourier Transform → Zero-padding → Inverse Fourier Transform → Filter Multiplication
(B) Filter Multiplication → Fourier Transform → Zero-padding → Inverse Fourier Transform
(C) Zero-padding → Fourier Transform → Filter Multiplication → Inverse Fourier Transform → Crop
(D) Zero-padding → Filter Multiplication → Fourier Transform → Inverse Fourier Transform

NODIA

2022

181. When comparing restoration techniques, why is the Constrained Least Squares filter often visually superior to the standard Wiener filter for complex degradations?
(A) It enforces a smoothness constraint to reduce artifacts.
(B) It eliminates the need for calculating inverse matrices.
(C) It calculates and corrects the noise variance automatically.
(D) It completely bypasses the spatial degradation function.

2022

182. Which interpolation method uses a mathematically complex surface-fitting polynomial over a 4×4 neighborhood to determine transformed pixel values, yielding highly smooth results?
(A) Nearest-neighbor
(B) Bilinear
(C) Linear spline
(D) Bicubic

2010

183. In color physics, when additive primary colors (Red, Green, Blue) are superimposed at equal, full intensity, what is the resulting color?
(A) Black
(B) White
(C) Gray

diagonal elements.

2023

203. The illumination-reflectance model inherently dictates that illumination components generally exhibit which frequency characteristic?
(A) Extremely high spatial frequencies
(B) Slowly varying low spatial frequencies
(C) Uniform distribution across all frequencies
(D) Periodic high-frequency spikes

2023

204. Which noise probability density function mathematically models a constant probability over a bounded interval between parameters a and b?
(A) Gaussian PDF
(B) Uniform PDF
(C) Erlang PDF
(D) Exponential PDF

2007

205. If an image is degraded by severe atmospheric turbulence (causing blurring) but contains no additive noise, which filter provides theoretically perfect restoration?
(A) Direct Inverse filter
(B) Median filter
(C) Min filter
(D) Adaptive local noise reduction filter

2006

206. Geometric transformations alter the spatial coordinates of image pixels. What fundamental process is required to assign intensity values to the newly calculated fractional coordinate positions?
(A) Frequency domain multiplication
(B) Morphological closing
(C) Gray-level interpolation
(D) Homomorphic filtering

2017

207. Which color model provides the most direct correlation to how the human visual system conceptually describes and differentiates colors?
(A) Cyan, Magenta, Yellow, Key (CMYK)
(B) Red, Green, Blue (RGB)
(C) Luminance and Chrominance (YCbCr)
(D) Hue, Saturation, Intensity (HSI)

2021

208. In pseudocolor processing using intensity slicing, the grayscale image is viewed as a 3D topographic surface where intensity represents elevation. Slicing planes parallel to the coordinate axes assign colors based on:
(A) The overall spatial frequency of the region
(B) The calculated directional gradient magnitude values
(C) The specific intensity interval of the pixels
(D) The median value of the surrounding neighbors

2010

209. Which fundamental rule governs the structuring element in morphological operations?
(A) It must be constrained strictly to a simple 3×3 square.
(B) It must have a defined origin and shape (e.g., cross, square).
(C) It must completely cover the entire active image coordinate matrix.
(D) It must contain only real scaling numbers strictly between 0 and 1.

2004

210. Given below are two statements, one is labelled as Assertion (A) and the other is labelled as Reason (R):
Assertion (A): Morphological gradient algorithms extract the sharp boundaries of objects in a grayscale image.
Reason (R): The morphological gradient is mathematically calculated as the difference between the dilation and the erosion of the image.
Based on the above statements, choose the correct option:
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is not the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2002

211. Which primary geometric structure is explicitly detected when applying the standard Hough Transform to an edge-mapped image?
(A) Unbroken straight lines
(B) Perfect circles
(C) B-spline curves
(D) Fractals

2018

212. In image thresholding, the objective of Otsu's algorithm is to find a threshold T that effectively minimizes which specific statistical variance?
(A) Between-class variance

Click Here to Buy book on Amazon

the transition from photopic (cone-based) to scotopic (rod-based) vision is known as:
(A) Chromatic aberration
(B) Purkinje shift
(C) Lateral inhibition
(D) Astigmatism

2002

194. If an image has a spatial resolution of 1024×1024 pixels and an 8-bit gray-level depth, what is the exact uncompressed storage requirement in bytes?
(A) 1024 Bytes
(B) 256 Kilobytes (KB)
(C) 1 Megabyte (MB)
(D) 8 Megabytes (MB)

2025

195. Which of the following conditions correctly identifies the connectivity requirement for a continuous path to exist between two pixels p and q?
(A) A path of adjacent pixels in V connects p and q.
(B) Both pixels share the same identical gray-level intensity.
(C) They are separated by exactly one Euclidean distance unit.
(D) They are positioned on opposite boundaries of the image.

2005

196. The transformation $s = c\log(1 + r)$ is particularly effective for visualizing what specific type of image data?
(A) Images containing low contrast levels restricted to dark regions
(B) Document scans containing strictly binary thresholded text
(C) Fourier spectrums containing very high dynamic range peaks
(D) High-key photographic scenes where most pixels are bright

2004

197. Which histogram operation specifically attempts to match an image's histogram to a uniform distribution, spreading the intensities to cover the full dynamic range?
(A) Histogram equalization
(B) Histogram specification
(C) Histogram stretching
(D) Histogram sliding

2002

198. Mask mode radiography relies mathematically on which basic arithmetic operation?
(A) Division
(B) Addition
(C) Multiplication
(D) Subtraction

2008

199. When analyzing spatial filters, which of the following represents a crucial advantage of the median filter over the spatial average (mean) filter?
(A) It behaves as a perfectly linear transformation operator.
(B) It removes impulse noise while preserving sharp edges.
(C) It operates faster by using standard matrix convolution.
(D) It inherently highlights directional diagonal boundaries.

2015

200. In the frequency domain, applying a Butterworth lowpass filter rather than an Ideal lowpass filter provides what primary visual benefit to the spatial image?
(A) Perfect preservation of the filter phase response
(B) Complete elimination of high-amplitude impulse noise
(C) Significant reduction of spatial ringing artifacts
(D) Achieving an exceptionally high image spatial resolution

NODIA

2014

201. Which discrete transform decomposes an image using localized, oscillating basis functions of varying scale and translation rather than infinite sinusoids, providing multiresolution analysis?
(A) Discrete Fourier Transform (DFT)
(B) Discrete Cosine Transform (DCT)
(C) Slant Transform
(D) Discrete Wavelet Transform (DWT)

2017

202. What specific mathematical property defines a transform as "orthogonal"?
(A) The inverse of the transform matrix equals its transpose.
(B) The transform mapping matrix contains only binary zeros and ones.
(C) The transform operates strictly in the continuous domain.
(D) The transform matrix consists of purely

(A) Probability Integral Transform
(B) Classical Bayes' conditional theorem
(C) Mathematical Central Limit Theorem
(D) Fundamental Law of Large Numbers

2025

126. During the image subtraction process, what preprocessing step is absolutely essential to ensure the resulting difference image is meaningful?
(A) Global histogram equalization applied to both source input images
(B) Complete conversion of both input images to a standardized binary format
(C) Exact spatial registration and alignment
(D) Highpass spatial filtering applied to both constituent input images

2011

127. Which of the following best describes the effect of a median filter applied to a corrupted image?
(A) It acts as a linear lowpass smoothing filter, uniformly blurring both high-frequency noise and structural edge details.
(B) It calculates the arithmetic mean, smoothing noise but severely blurring sharp edges.
(C) It calculates the directional spatial gradient magnitude, significantly enhancing high-frequency outer edge structures.
(D) It replaces pixels with the neighborhood median, removing impulse noise while preserving edges.

2017

128. In frequency domain filtering, the Fast Fourier Transform (FFT) requires the image dimensions to conform to which structural constraint for optimal algorithmic efficiency?
(A) Both spatial dimensions must be prime integer numbers.
(B) The source input image must be a perfect geometric square.
(C) The dimensions must be integer powers of 2.
(D) The spatial dimensions must strictly be odd integers.

2021

129. The Haar transform differs fundamentally from the Fourier transform in that its basis functions are highly localized in which domain?
(A) The continuous frequency domain only
(B) Both spatial and frequency domains
(C) The discrete spatial domain only
(D) The imaginary phase domain only

2014

130. Consider the following statements regarding advanced unitary transforms:
I. The KLT is data-dependent and requires computing the covariance matrix.
II. SVD compresses image data by storing only the largest singular values and corresponding vectors.
III. The KLT basis functions are fixed sinusoids.
Which of the above statements are correct?
(A) I and III
(B) I and II
(C) II and III
(D) II

2015

131. In the homomorphic filtering framework, after filtering the log-transformed image in the frequency domain, what is the mandatory final mathematical step?
(A) Applying an exponential transformation
(B) Computing the complete frequency magnitude spectrum
(C) Taking the natural logarithm of the filtered image
(D) Performing a structuring morphological dilation step

2003

132. The process of estimating a degradation function by analyzing a small, high-contrast subimage containing a simple structure or isolated feature within the degraded image itself is termed:
(A) Estimation by mathematical modeling
(B) Estimation by experimentation
(C) Estimation by image observation
(D) Estimation by Wiener filtering

2007

133. The Constrained Least Squares filter specifically addresses a major mathematical weakness of the basic inverse filter by doing what?
(A) Avoiding division by near-zero degradation values using regularization
(B) Assuming zero noise variance throughout the entire image reconstruction process
(C) Performing all mathematical restoration calculations strictly in the spatial domain
(D) Assuming that the underlying degradation function is equivalent to an identity matrix

2022

134. Which spatial transformation model requires mapping coordinates using interpolation because transformed pixels rarely align perfectly with the discrete output grid?

Downloaded from www.pdf.tube

(B) Total global variance
(C) Within-class variance
(D) Cross-covariance

2010

213. When analyzing the perimeter of an object represented on a discrete grid, which representation method calculates a sequence of directional line segments connecting boundary pixels?
(A) Freeman chain codes
(B) Polygonal approximations
(C) Fourier descriptors
(D) Textural signatures

2023

214. Which invariant feature allows topological descriptors (like the Euler number) to robustly describe regions?
(A) They are completely unaffected by affine transformations.
(B) They preserve exact perimeter lengths regardless of scale.
(C) They inherently correct multi-channel chromatic aberrations.
(D) They remain constant under non-tearing deformations.

2013

215. What is the fundamental cause of spatial redundancy in a digital image?
(A) Coding individual symbols with unnecessary large bit lengths
(B) Correlation and similarity between neighboring pixel values
(C) Inability of the human eye to resolve high frequency variations
(D) Excessive presence of random additive Gaussian sensor noise

2024

216. Which compression standard utilizes block-based Discrete Cosine Transform (DCT), quantization, and Huffman coding to achieve lossy compression of continuous-tone still images?
(A) LZW
(B) Run-Length Encoding
(C) JPEG
(D) CCITT Group 4

2004

217. In the context of visual perception, the phenomena where the perceived brightness of a region is altered by the intensity of its surrounding area is known as:
(A) Mach band effect
(B) Chromatic adaptation
(C) Visual masking
(D) Simultaneous contrast

2006

218. According to the standard digital image coordinate system, if an image has dimensions $M \times N$ (rows $\times$ columns), the coordinates of the bottom-right pixel are:
(A) $(M-1, N-1)$
(B) (M, N)
(C) $(N-1, M-1)$
(D) (N, M)

NODIA

2021

219. Which relationship property must hold mathematically true for an adjacency metric to be considered an equivalence relation?
(A) Non-linearity and scale invariance
(B) Transitivity, reflexivity, and symmetry
(C) Commutativity and distributivity
(D) Positive definiteness

2005

220. Match the spatial transformations in List I with their characteristic definitions in List II.
List I: (Transformations)
P. Image Negative
Q. Log Transformation
R. Power-law (Gamma)
S. Contrast Stretching
List II: (Definitions)
1. $s = c\log(1+r)$
2. $s = L-1-r$
3. Piecewise linear expansion of dynamic range
4. $s = cr^{\gamma}$
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-1, R-4, S-3
(C) P-4, Q-3, R-1, S-2
(D) P-2, Q-4, R-1, S-3

2022

221. Which specific histogram processing technique uses the cumulative distribution function (CDF) evaluated over a highly localized sliding window rather than the global image?
(A) Adaptive (local) histogram equalization
(B) Standard global histogram equalization
(C) User-specified target histogram specification
(D) Dynamic range histogram stretching

2024

222. In arithmetic image operations, bit-plane slicing relies on which mathematical property of the integer pixel representation?
(A) Base-10 logarithms

same scene. This method assumes that the noise is additive, uncorrelated, and has a zero mean. However, it is not effective for multiplicative or periodic noise, which does not cancel out through simple averaging.

31. (D) Linear filters compute weighted sums of pixels; non-linear filters use pixel ranking or logic.
The fundamental distinction between spatial filters lies in their mathematical operations. Linear filters perform convolution or correlation by calculating a weighted sum of neighborhood pixels. Conversely, non-linear filters do not use weighted sums; instead, they operate based on pixel ranking, logical conditions, or statistical sorting, as demonstrated by the median filter.

32. (C) The average gray-level intensity of the entire image
In the two-dimensional Discrete Fourier Transform, the zero-frequency term, commonly called the DC coefficient, represents the average value of all pixels in the spatial domain. This coefficient is mathematically proportional to the sum of all pixel intensities in the image, carrying the global illumination level rather than directional or high-frequency edge information.

33. (B) Discrete Cosine Transform (DCT)
The Discrete Cosine Transform is a highly effective unitary transform that offers exceptional energy compaction, concentrating most image information in a few low-frequency coefficients. Because its performance closely approaches the statistically optimal Karhunen-Loève transform without requiring data-dependent basis functions, it has become the standard transform for JPEG image compression systems.

34. (D) They are orthogonal matrices.
Singular Value Decomposition represents an image matrix as the product of three constituent matrices. Within this formulation, the left singular matrix and the right singular matrix are mathematically proven to be orthogonal matrices. This means that their columns represent mutually perpendicular unit vectors, which preserve vector lengths and angles during spatial transformations.

35. (A) $f(x, y) = i(x, y) \times r(x, y)$
The illumination-reflectance model represents an image as the direct product of two distinct components: the illumination field and the reflectance function of objects. This multiplicative relationship requires non-linear processing, such as homomorphic filtering, to separate the slow-varying illumination from the fast-varying reflectance details in the frequency domain.

36. (C) Random noise associated with laser and radar imaging
The Erlang, or Gamma, probability density function is a noise model frequently used to characterize the degradations found in laser, radar, and coherent imaging systems. It describes noise that has a skewed probability distribution, helping researchers model speckle noise and design specialized filters to restore degraded images in these advanced modalities.

37. (A) Wiener filtering
Wiener filtering is an optimal restoration technique that minimizes the mean square error between the estimated image and the original uncorrupted image. It achieves this optimization by incorporating prior statistical knowledge of both the system's degradation function and the power spectra of both the noise and the original undegraded image.

38. (D) Unmapped holes or overlapping pixels
During geometric rotations, applying forward mapping can cause severe artifacts because integer coordinates in the source image are mapped to non-integer coordinates in the target. This mismatch inevitably results in unmapped pixel locations, appearing as empty holes, or multiple pixels mapping to the same target coordinate. Inverse mapping avoids this defect.

39. (B) Subtractive mixing of CMY inks yields a muddy brown instead of black.
The CMYK color model incorporates a dedicated black channel because the physical subtractive mixing of pure cyan, magenta, and yellow inks on paper does not produce a true, deep black color. Instead, combining these three primary subtractive inks results in a muddy, dark brown shade, making black ink essential for high-quality printing.

40. (C) I, II and III
Full-color image processing can be performed in several ways. Independent color transformations can be applied to individual RGB channels, but spatial smoothing of these channels independently

Click Here to Buy book on Flipkart

(D) Lab

2025

232. When performing full-color image processing, what is the primary structural difference between processing RGB channels independently versus processing as a vector in the color space?
(A) Independent processing preserves original hue ratios perfectly.
(B) Vector processing is limited strictly to frequency domain filters.
(C) Vector processing maintains cross-channel correlation.
(D) Independent processing converts the image to the HSI model.

2025

233. The morphological transformation defined as the Minkowski subtraction of a structuring element from an image is identical to which basic operation?
(A) Dilation
(B) Opening
(C) Closing
(D) Erosion

2015

234. Which advanced morphological operation relies fundamentally on identifying a set of connected components that share a specific geometric trait and eliminating the rest?
(A) Connected Components Extraction
(B) Morphological Hit-or-Miss Transform
(C) Convex Hull and Boundary Closure
(D) Granulometry and Size Distribution

2024

235. The Hough Transform utilizes a polar coordinate representation ($\rho = x\cos\theta + y\sin\theta$) rather than slope-intercept ($y = mx + c$) to avoid which critical mathematical problem?
(A) Complex numbers generated by negative intercepts
(B) Infinite values of slope m for vertical lines
(C) Non-linear sinusoidal curves in parameter space
(D) The inability to process grayscale pixels

2021

236. The watershed segmentation algorithm prevents the merging of separate "catchment basins" by mathematically constructing which structural element?
(A) Bounding boxes
(B) Watershed lines
(C) Convex hulls
(D) Delaunay triangulations

2003

237. When constructing a polygonal approximation of a boundary, the Minimum Perimeter Polygon (MPP) technique fundamentally simulates what physical action?
(A) A rubber band snapping tight around obstacles
(B) A water drop expanding to fill a flat basin
(C) A continuous string uncoiling from a metal cylinder
(D) A rigid rod sliding smoothly along a contour

2004

238. Co-occurrence matrices are a highly effective statistical tool for defining which complex regional characteristic?
(A) Boundary perimeter length
(B) Convex deficiency
(C) Image texture
(D) Euler number

2018

239. Which error metric directly calculates the average squared difference between the actual original pixels and the lossy reconstructed pixels?
(A) Peak Signal-to-Noise Ratio (PSNR)
(B) Structural Similarity Index (SSIM)
(C) Entropy
(D) Mean Square Error (MSE)

2012

240. Consider the following steps in lossless predictive image coding:
I. Determine the prediction error
II. Form the predicted pixel value from neighbors
III. Encode the prediction error using variable-length coding
IV. Transmit the encoded error
What is the correct sequential order of these steps?
(A) I, II, III, IV
(B) II, III, I, IV
(C) II, I, III, IV
(D) III, II, I, IV

2005

241. What defines the fundamental limit of spatial resolution in an imaging sensor array?
(A) The analog-to-digital converter bit depth
(B) The density of the sensor photosites
(C) The color model utilized for processing
(D) The maximum transfer speed of the bus

Downloaded from www.pdf.tube

10. (C) (A) is true but (R) is false
The Karhunen-Loève transform is mathematically proven to be the optimal linear transform for data compression because it completely decorrelates the input data. However, its basis functions are not fixed; instead, they are derived directly from the covariance matrix of the input image, making the transform highly data-dependent and computationally intensive to calculate.

11. (B) Natural logarithm
Homomorphic filtering processes images by separating the illumination and reflectance components, which are multiplicatively combined in the spatial domain. Applying a natural logarithm transforms this multiplicative relationship into an additive one. Once the components are additive, linear frequency domain filtering techniques can be applied directly to isolate and suppress the low-frequency illumination.

12. (B) Rayleigh noise
Rayleigh noise is characterized by an asymmetrical probability density function that displays a single distinct peak and a skewed tail stretching toward the higher intensity values. This mathematical model is frequently observed in range imaging, active radar, and coherent laser systems, where the degradation naturally exhibits this specific skewed statistical profile.

13. (A) It amplifies noise components at frequencies where the degradation function is near zero.
Basic inverse filtering attempts to restore a degraded image by dividing the Fourier transform of the blurred image by the degradation function. However, when additive noise is present, this division catastrophically amplifies the noise at high frequencies where the degradation function values are very close to zero, completely dominating the restored image.

14. (C) Nearest-neighbor interpolation
Nearest-neighbor interpolation is a simple geometric spatial transformation technique that determines the intensity of a remapped pixel by finding the closest integer coordinate in the source grid. It assigns this exact intensity directly without performing any weighted calculations, which makes it computationally fast but susceptible to severe aliasing and blocky visual artifacts.

15. (D) Hue
In the HSI color model, hue represents the dominant wavelength of light perceived by an observer, corresponding to the pure color itself. This attribute allows users to distinguish between different colors, such as red, yellow, or blue, and is measured as an angle between zero and three hundred sixty degrees around the color circle.

16. (C) Assigning distinct colors to ranges of gray levels in a monochrome image
Intensity slicing is a fundamental pseudocolor image processing technique where the entire gray-scale range of a monochrome image is divided into distinct intervals. Each interval is then assigned a unique, pre-selected color. This visual transformation simplifies human analysis because the human eye can distinguish thousands of colors but only a few dozen gray levels.

17. (B) Erosion
Erosion is a fundamental mathematical morphology operation that shrinks the size of foreground objects by removing boundary pixels. This process is determined by a structuring element, which moves across the image and keeps only those pixels where the element fits entirely within the foreground, effectively eliminating small details and narrowing connected structures.

18. (D) Enhancing local detail under non-uniform scene illumination
The morphological top-hat transformation is defined as the subtraction of an opened image from the original image. This operation effectively isolates bright features that are smaller than the structuring element against a dark background. It is widely utilized to correct non-uniform illumination and enhance local contrast details in unevenly lit scenes.

19. (A) A point
The Hough transform uses a parameter space parameterized by angle and distance to detect geometric shapes. A straight line in the spatial coordinate plane is represented by a single point in this parameter space, because all collinear points along that line correspond to sinusoidal curves that intersect at a single coordinate in the parameter space.

20. (A) P-2, Q-3, R-4, S-1
Image segmentation methods rely on distinct mathematical principles to group pixels. Otsu's

NODIA

binary representation.

2019

252. Which spatial noise distribution is mathematically characterized by a probability density function exhibiting a distinctive bell-shaped curve?
(A) Erlang PDF
(B) Gaussian PDF
(C) Uniform PDF
(D) Rayleigh PDF

2011

253. Which restoration algorithm evaluates the local neighborhood variance to intelligently switch between a mean filter (in smooth areas) and no filtering (at sharp edges)?
(A) Adaptive local noise filter
(B) Direct spatial Inverse filter
(C) Non-linear Geometric Mean filter
(D) Standard global Wiener filter

2024

254. When an image undergoes geometric scaling, which spatial interpolation technique minimizes the visually disruptive "blocky" artifacts while requiring significant computational overhead?
(A) Nearest-neighbor interpolation
(B) Pixel replication
(C) Bicubic interpolation
(D) Sub-sampling without filtering

2025

255. In the HSI color model, which parameter is mathematically defined as the angle around the vertical color axis, starting with red at 0 degrees?
(A) Saturation
(B) Intensity
(C) Brightness
(D) Hue

2023

256. Which operation is considered the most mathematically correct way to adjust the overall brightness (intensity) of a full-color image without altering its perceived color tint?
(A) Add a constant uniformly to all R, G, and B components.
(B) Multiply the Hue channel by a constant scaling factor.
(C) Convert to HSI, adjust Intensity, and convert back.
(D) Perform a logical XOR operation on the active RGB matrix.

2005

257. Which morphological operation effectively isolates small, specific foreground features by destroying large structural components and subtracting the result from the original image?
(A) Morphological gradient
(B) Top-hat transform
(C) Boundary extraction
(D) Convex hull

2012

258. Region growing algorithms inherently depend on evaluating a logical predicate $P(R)$ over a set of pixels. What does this predicate specifically define?
(A) The spatial Euclidean distance to the nearest boundary.
(B) The absolute coordinate location of the initial seed point.
(C) The expected geometric shape of the resulting active region.
(D) The homogeneity criteria required to append a pixel.

2001

259. When extracting object boundaries, which local processing algorithm connects adjacent edge points based solely on gradient magnitude and direction proximity?
(A) Local edge linking
(B) Global thresholding
(C) Morphological dilation
(D) Spatial median filtering

2021

260. Which statistical region descriptor evaluates the relative occurrence of pairs of pixels with specific intensities at a specified spatial displacement?
(A) Spatial regional moments
(B) Freeman chain codes
(C) Co-occurrence matrix
(D) Boundary shape numbers

2009

261. In the context of image compression fidelity, which term describes data loss that is mathematically measurable but totally imperceptible to the human observer?
(A) Psychovisual redundancy
(B) Coding redundancy
(C) Spatial redundancy
(D) Temporal redundancy

Click Here to Buy book on Amazon

2011

262. Which widely used image file format intrinsically utilizes LZW (Lempel-Ziv-Welch) lossless compression?
(A) BMP
(B) JPEG
(C) RAW
(D) GIF

2004

263. When calculating spatial distance in digital image geometry, what is the City-block distance D_4 between the origin $(0,0)$ and the coordinate $(3,4)$?
(A) 5
(B) 7
(C) 12
(D) 25

2018

264. What fundamental limitation dictates why exact, mathematically perfect image restoration via inverse filtering is virtually impossible in real-world scenarios?
(A) Digital coordinate arrays are fundamentally limited to fixed color palettes.
(B) The Discrete Fourier Transform is unable to compute floating-point data.
(C) Noise dominates at high frequencies where degradation approaches zero.
(D) Spatial convolution operations inevitably destroy vital phase information.

2021

265. Which fundamental frequency domain concept defines the mathematical relationship where convolution in the spatial domain equals multiplication in the frequency domain?
(A) Parseval's Theorem
(B) Nyquist-Shannon Theorem
(C) Euler's Identity
(D) Convolution Theorem

2016

266. A 2D Haar Transform is highly efficient for analyzing images with which structural characteristics?
(A) Abrupt transitions and constant-intensity regions
(B) Purely continuous, smoothly varying spatial gradients
(C) Infinite sinusoidal and periodic harmonic patterns
(D) Images degraded heavily by random unipolar noise

2014

267. Which geometric transformation explicitly requires knowledge of four distinct tie-points (control points) in both the input and output images to compute its coefficients?
(A) Uniform spatial translation
(B) Bilinear spatial mapping
(C) Isotropic uniform scaling
(D) Coordinate-based pure rotation

NODIA

2002

268. Which boundary representation descriptor calculates a unique set of 7 mathematical values that remain strictly invariant to translation, scale, and rotation?
(A) Fourier phase angles
(B) Hu's Invariant Moments
(C) Shape numbers
(D) Polygonal vertices

2006

269. The fundamental objective of the morphological watershed algorithm is to segment an image into distinct regions separated by continuous boundaries. It achieves this by finding the:
(A) Ridgelines of the gradient image
(B) Peaks of the global intensity histogram
(C) Zero-crossings of the Laplacian operator
(D) Medial axis transform of the skeleton

2007

270. In the mathematical formulation of predictive lossy compression, the primary purpose of the quantizer loop within the encoder is to:
(A) Guarantee mathematically guaranteed error-free lossless reconstruction.
(B) Convert the spatial image representation into the frequency domain.
(C) Prevent error accumulation by matching encoder and decoder values.
(D) Calculate the statistical lower bound of the image's entropy limit.

****

ANSWERS

1. (B) Logarithmic response to light intensity
Human visual perception of light intensity variations is highly non-linear and exhibits a logarithmic relationship. This biological characteristic is described by the Weber-Fechner law, demonstrating that the human eye is more sensitive to changes in dark regions than in bright regions. Consequently, logarithmic models are widely used to simulate human psychovisual response to brightness.

2. (D) Greater than $2f_{\max}$
The Nyquist-Shannon sampling theorem establishes that reconstructing a continuous signal from its samples requires a sampling frequency strictly greater than twice the highest frequency component of the signal. If the sampling rate is exactly or less than this threshold, aliasing artifacts corrupt the digital representation. Thus, sampling must exceed this limit to preserve original details.

3. (A) Chessboard distance
The chessboard distance represents the maximum absolute difference between the coordinates of two pixels in a discrete grid. It is geometrically defined such that pixels with a distance of one form a square centered around the target pixel. This spatial metric is highly valuable for path planning and neighborhood analysis in digital image processing operations.

4. (C) Contrast stretching
Contrast stretching is a spatial domain point processing technique designed to expand the dynamic range of selected gray levels within a specified narrow interval. By selectively altering the mapping slope for these specific values, this operation enhances local features and details in low-contrast images while leaving other intensity levels relatively unaffected or compressed.

5. (A) Uniform distribution
Histogram equalization is designed to transform the intensity values of an image so that the resulting probability density function of gray levels closely matches a uniform distribution. This uniform distribution maximizes the entropy of the image, thereby enhancing global contrast by distributing the pixel intensities evenly across the entire available dynamic range.

6. (D) To isolate structural changes by removing static background anatomy
Mask mode radiography utilizes digital image subtraction to eliminate stationary anatomical background features, such as bones or organs, from a clinical sequence. By subtracting a pre-contrast mask image from subsequent post-contrast images, doctors can isolate and clearly visualize dynamic physiological changes, such as blood flow through vessels, without background obstruction.

7. (B) A Laplacian filter directly yields a sharply enhanced image without adding the original.
The Laplacian is a second-order derivative operator that highlights rapid intensity changes, such as edges, but results in an image with zero-valued backgrounds. To achieve a sharpened, visually enhanced image, this derivative output must be subtracted from or added to the original image. Simply calculating the Laplacian alone does not yield a completed sharpened image.

8. (C) Gaussian lowpass filter
A Gaussian lowpass filter has a smooth frequency transition curve that is also a Gaussian function. Because the Fourier transform of a Gaussian function is itself a Gaussian function, this filter does not introduce any ringing artifacts in the spatial domain. This characteristic makes it highly superior to ideal or Butterworth filters for smoothing.

9. (D) Hadamard Transform
The Hadamard transform is a discrete unitary transform whose basis vectors are composed entirely of alternating square waves containing values of positive one and negative one. This specific mathematical structure makes the transform extremely efficient computationally, as it requires only additions and subtractions rather than complex multiplications to process digital image data.

Downloaded from www.pdf.tube

2017

242. According to Shannon's Sampling Theorem, the continuous signal can be perfectly reconstructed from discrete samples only if the signal possesses what specific property?
(A) It must have infinite duration.
(B) It must be perfectly periodic.
(C) It must contain only positive values.
(D) It must be strictly band-limited.

2005

243. Two pixels are defined as m-adjacent if they are diagonally adjacent and their respective 4-neighborhoods share what specific characteristic?
(A) Their intersection contains no pixels of the set V.
(B) Their intersection contains exactly two pixels of the set V.
(C) They are separated by exactly one background pixel element.
(D) They share the identical global image coordinate origin.

2025

244. A power-law transformation $s = cr^{\gamma}$ with $\gamma < 1$ maps a narrow range of dark input values into what output distribution?
(A) A similarly narrow range of dark output values
(B) A perfectly inverted linear negative
(C) A wider range of brighter output values
(D) A pure binary map

2004

245. When applying histogram equalization to a discrete image array, the resulting histogram is rarely perfectly flat (uniform). What mathematical constraint causes this?
(A) Discrete gray levels cannot be fractionally divided.
(B) The image contains significant spatial aliasing.
(C) The equalization function must be strictly non-monotonic.
(D) The probability distribution function exceeds unity values.

2021

246. Image multiplication is a pixel-by-pixel operation most frequently utilized in image processing for which explicit purpose?
(A) Correcting perspective geometric distortions
(B) Removing high-frequency salt and pepper noise
(C) Enhancing global contrast dynamic intensity range
(D) Masking out arbitrary regions of an image

2025

247. The Laplacian is a linear derivative operator that highlights rapid intensity transitions. Why is the Laplacian rarely used alone for edge detection in noisy images?
(A) It fundamentally ignores directional vertical edges.
(B) It is highly sensitive to high-frequency noise.
(C) It requires transformation into the frequency domain.
(D) It reduces the whole image to a single scalar value.

2021

248. The mathematical formulation of the 2D Discrete Fourier Transform expresses an image as a linear combination of which complex functions?
(A) Splines
(B) Orthogonal polynomials
(C) Complex exponentials
(D) Step functions

NODIA

2011

249. Which mathematical property of the Discrete Cosine Transform (DCT) matrix ensures that the inverse transform matrix is simply its transpose?
(A) Linearity
(B) Periodicity
(C) Conjugate symmetry
(D) Orthogonality

2025

250. Which algorithm analytically defines an orthogonal linear transformation that maps data into a new coordinate system such that the greatest variance lies along the first coordinate (principal component)?
(A) Karhunen-Loève Transform (KLT)
(B) Fast Fourier Transform algorithm (FFT)
(C) Discrete Wavelet Transform (DWT)
(D) Hough Transform (HT)

2003

251. By independently filtering the illumination and reflectance components, homomorphic filtering achieves which specific structural modification?
(A) It sharpens illumination shadows and blurs reflectance textures.
(B) It compresses illumination range and enhances reflectance contrast.
(C) It perfectly restores complex uniform linear motion blur degradations.
(D) It transforms the entire image into a purely

method maximizes between-class variance to find an optimal threshold, while region growing appends adjacent pixels to seeds. The watershed algorithm treats intensities as topographic elevations, and split-and-merge techniques recursively partition and join sub-regions based on homogeneity predicates.

21. (A) Freeman chain code
The Freeman chain code is a boundary descriptor that represents the contour of an object using a sequence of direction vectors on a discrete grid. By specifying the direction of next steps along the boundary with numerical codes, it provides a compact representation that is highly useful for shape analysis and object recognition tasks.

22. (D) $E = C - H$
The Euler number is a fundamental topological descriptor that remains invariant under rubber-sheet deformations. In a two-dimensional binary image, the Euler number is mathematically defined as the total number of connected components minus the total number of holes present in those components. This metric provides a robust, scale-invariant feature for shape description.

23. (B) Spatial redundancy
Spatial redundancy occurs in digital images because neighboring pixels are highly correlated, meaning that the intensity values of adjacent pixels are often very similar or identical. This structural probability of gray-level transitions allows compression algorithms to represent the image using fewer bits by predicting or encoding the differences between neighboring pixels.

24. (C) Assigning shorter codes to more frequently occurring symbols
Huffman coding is an entropy-based compression algorithm that achieves data reduction by assigning variable-length codes to source symbols based on their probabilities. More frequently occurring symbols are assigned shorter binary codes, while rare symbols receive longer codes. This approach minimizes the average code length, thereby maximizing coding efficiency without losing any image information.

25. (D) Digital image coordinate system
The digital image coordinate system is a standard representation matrix where the origin is positioned at the top-left corner of the image. The row index increases downward, and the column index increases to the right. This convention differs from the standard Cartesian coordinate system and matches the sequential raster scanning of display devices.

26. (A) Spatial aliasing or Moiré patterns
Sampling an analog image below the Nyquist rate leads directly to spatial aliasing, because high-frequency details are mapped incorrectly to lower frequencies. This undersampling manifests visually as distorted patterns, jagged edges, or Moiré effects, where fine repetitive details are completely lost and replaced by artificial, low-frequency geometric structures in the reconstructed image.

27. (B) 8-adjacency: Horizontal, vertical, and diagonal neighbors
Eight-adjacency in a digital grid is defined when two pixels share either an edge or a corner, meaning they are horizontal, vertical, or diagonal neighbors. This connectivity definition is essential for establishing paths, boundaries, and connected components within digital images, ensuring that all spatial relationships in the immediate neighborhood are fully accounted for.

28. (B) Highlighting key gray levels while preserving overall context
Gray-level slicing with a background-preserving piecewise linear transformation is specifically used to highlight a selected range of intensities while keeping the remaining gray levels unchanged. This allows important features within a specific intensity band to be enhanced and easily analyzed, without losing the surrounding spatial context and background information of the image.

29. (A) Cumulative Distribution Function
Histogram matching, or specification, requires calculating the cumulative distribution function of both the original image and the desired target distribution. By mapping the cumulative probabilities of the original gray levels to those of the target distribution through an inverse transformation, the image is modified to match the specified histogram shape precisely.

30. (C) I and III
Image averaging is a powerful noise reduction technique that significantly improves the signal-to-noise ratio by averaging multiple images of the

Click Here to Buy book on Flipkart

(B) Hexadecimal modulo arithmetic
(C) Base-2 binary numeral system
(D) Floating-point mantissas

2018

223. What mathematical operation does an image convolution fundamentally perform when an asymmetric kernel is applied?
(A) Direct pixel-by-pixel multiplication of active elements
(B) Direct summation of the spatial kernel weight elements
(C) Division of the image matrix by the kernel determinant
(D) Kernel rotation by 180 degrees and cross-correlation

2008

224. Which spatial domain characteristic causes the "ringing" artifact associated with Ideal lowpass filters in the frequency domain?
(A) The filter's non-linear phase response
(B) The high amplitude of un-filtered Gaussian noise
(C) The sharp frequency cutoff discontinuity
(D) Lack of zero-padding before transformation

2014

225. Which distinct advantage makes the Discrete Cosine Transform (DCT) vastly preferable to the Discrete Fourier Transform (DFT) for image compression?
(A) It requires no arithmetic operations other than additions.
(B) It operates with real numbers and packs energy efficiently.
(C) It fundamentally performs error-free lossless compression.
(D) It isolates primary color channels directly inside the spatial domain.

2004

226. The Singular Value Decomposition (SVD) represents an image as a weighted sum of rank-1 matrices. How does this facilitate data reduction?
(A) By keeping eigenvectors of the smallest singular values.
(B) By dropping all singular values that are largest in magnitude.
(C) By replacing all singular value diagonal elements with one.
(D) By reconstructing using only the largest singular values.

NODIA

2003

227. Which filtering technique attempts to normalize extreme illumination variations (such as deep shadows) while simultaneously amplifying the high-frequency reflectance details?
(A) Homomorphic filtering
(B) Wiener filtering
(C) Median filtering
(D) Constrained Least Squares filtering

2001

228. Which noise probability density function mathematically models the random emission of photons in low-light environments, such as astronomical imaging or X-rays?
(A) Uniform PDF
(B) Salt-and-Pepper PDF
(C) Poisson PDF
(D) Rayleigh PDF

2024

229. If an image is completely blurred due to linear uniform motion but lacks any additive noise, how does the inverse filter theoretically perform?
(A) It restores the image except at degradation zero-crossings.
(B) It completely destroys the image structure due to phase inversion.
(C) It maps all pixels uniformly to a single constant intensity value.
(D) It behaves identically to a standard lowpass spatial mean filter.

2009

230. Determine the correct sequence of steps for applying a spatial geometric transformation using inverse mapping.
(A) Apply spatial transform matrix → Calculate source coordinate → Interpolate gray level → Determine target coordinate
(B) Interpolate gray level → Apply spatial transform matrix → Calculate target coordinate → Determine source coordinate
(C) Determine source coordinate → Apply inverse spatial transform matrix → Interpolate gray level → Calculate target coordinate
(D) Calculate target coordinate → Apply inverse spatial transform matrix → Determine source coordinate → Interpolate gray level

2014

231. Which color model utilizes physical subtractive properties of ink on paper to render colors?
(A) RGB
(B) CMYK
(C) HSI

can introduce false colors and alter the hue. Utilizing the HSI color space avoids this issue by isolating intensity, allowing spatial processing without altering color information.

41. (D) Erosion followed by Dilation
Morphological opening is mathematically defined as the erosion of an image by a structuring element, followed immediately by the dilation of the result using the same structuring element. This operation is highly effective for smoothing object contours, breaking narrow join lines, and eliminating thin protrusions and small foreground noise.

42. (A) $A - (A \ominus B)$
Boundary extraction of a binary set is achieved by eroding the original set with a structuring element and then subtracting this eroded version from the original set. Since erosion shrinks the foreground object, subtracting it leaves behind only the outer boundary pixels, yielding a clean, single-pixel-wide contour of the shape.

43. (B) The zero-crossing point
Second-derivative operators, such as the Laplacian, produce a zero-crossing point at locations of rapid intensity transitions. A zero-crossing occurs where the second derivative changes sign, representing the local maximum of the first derivative. Consequently, edge detection algorithms identify these zero-crossings to locate the exact center of an edge.

44. (B) A single threshold value applied uniformly across the entire image
A global threshold in image segmentation is a single intensity value applied uniformly to every pixel across the entire image. Pixels with intensities above this threshold are classified as foreground, while those below are classified as background, which works optimally when the image histogram exhibits a clear bimodal distribution.

45. (A) Medial axis transform (skeletonization)
The medial axis transform, commonly known as skeletonization, reduces a two-dimensional region to a one-dimensional representation. This representation is defined as the locus of the centers of all maximal inscribed circles within the boundary of the region, effectively capturing the structural shape and topology of the object in a simplified format.

46. (C) The spatial relationship and frequencies of pixel pairs
Gray-level co-occurrence matrices capture texture information by calculating how often pairs of pixels with specific intensities and spatial relationships occur within an image. This statistical approach measures the relative frequency of pixel combinations at defined distances and orientations, providing key texture descriptors like contrast, correlation, energy, and homogeneity.

47. (D) Objective fidelity criteria for reconstructed quality
Peak Signal-to-Noise Ratio is widely used in image compression as an objective fidelity metric to measure the quality of a reconstructed image relative to the original. By calculating the ratio between the maximum possible power of a signal and the corrupting noise, it provides a quantitative assessment of compression loss.

NODIA

48. (C) Dictionary-based error-free coding
LZW coding is a lossless compression algorithm that operates on a dictionary-based mechanism. It dynamically builds a dictionary of recurring pixel sequences during the encoding process, replacing frequent patterns with short index codes. Because no information is discarded, the original image can be reconstructed with absolute mathematical fidelity during decoding.

49. (B) Higher frequency, shorter wavelength
X-rays used in medical imaging occupy a region of the electromagnetic spectrum characterized by significantly higher frequencies and shorter wavelengths compared to visible light. This high-frequency, high-energy profile allows X-ray photons to penetrate soft human tissues, enabling the capture of inner anatomical structures on digital sensors or film.

50. (C) I, IV and V
Spatial resolution is determined by spatial sampling, not quantization, while the Nyquist criterion requires sampling at more than twice the highest frequency. Additionally, spatial interpolation cannot recover true high-frequency information once it is lost to aliasing. Therefore, these statements are incorrect regarding digital image sampling, resolution, and reconstruction principles.

51. (A) m-connectivity
Mixed connectivity, or m-connectivity, is a pixel adjacency definition introduced to eliminate the ambiguity of multiple paths that often occurs when tracing boundaries using standard eight-connectivity. By applying conditional rules that restrict diagonal paths when horizontal or vertical paths exist, m-connectivity ensures unique and unambiguous paths along digital boundaries.

52. (C) It compresses the dark pixels while expanding the bright pixels.
Applying a power-law transformation with a gamma value strictly greater than one compresses the lower intensity, dark values while expanding the higher intensity, bright values. This non-linear mapping curves downward, causing the overall image to appear darker, which is highly useful for enhancing details in bright areas.

53. (A) At the higher end (near $L-1$)
When a digital image contains predominantly bright pixels with very low contrast, its histogram will be heavily concentrated in a narrow band near the higher end of the intensity scale, close to the maximum value of the gray-scale range. This indicates a lack of dark values and overall low contrast.

54. (D) Bit plane 7 (Most Significant Bit)
In an eight-bit digital image, bit plane seven represents the most significant bit. This plane contains the high-order bits that contribute the vast majority of the visually significant structural information and spatial details, whereas lower-order bit planes capture fine, subtle variations that often resemble random noise.

55. (B) Sobel operator
The Sobel operator is a first-order derivative edge detector that utilizes two three-by-three convolutional masks to approximate horizontal and vertical gradients. A key feature of the Sobel masks is the incorporation of smoothing orthogonal to the derivative direction, which significantly reduces high-frequency noise sensitivity compared to other simple operators.

56. (C) Fast Fourier Transform (FFT) algorithm
The Fast Fourier Transform is an exceptionally efficient algorithm used to calculate the discrete Fourier transform of an image. By exploiting mathematical symmetries and decomposing the transform into smaller, recursive calculations, the FFT reduces the computational complexity from a quadratic relationship to a highly manageable logarithmic time complexity.

57. (D) It effectively minimizes implicit periodic boundary discontinuities.
The Discrete Cosine Transform is highly suitable for block-based compression because it implicitly mirrors the image block boundaries, making the boundary transitions even. This effectively minimizes the high-frequency periodic boundary discontinuities that occur when transforming small blocks, thereby preventing severe blocky compression artifacts in the reconstructed image.

58. (A) Image data compression
Singular Value Decomposition can be used for image compression by ordering the singular values in decreasing magnitude and retaining only the largest ones. By discarding the smallest singular values, the image matrix can be closely approximated using a fraction of the original data, significantly reducing storage requirements.

59. (B) Illumination
Within the framework of the illumination-reflectance model, the illumination component represents the amount of light incident on a scene. This component is generally assumed to vary slowly across the spatial domain, meaning it corresponds to the low-frequency spectral components of the image, while reflectance represents rapid detail changes.

60. (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
Salt-and-pepper noise consisting of sharp impulse spikes is not effectively removed by a linear mean filter. Instead of eliminating the impulses, the mean filter averages them with surrounding pixels, which blurs the noise spikes into the background and degrades the image details. A non-linear median filter is required instead.

61. (A) A measure of smoothness via the Laplacian
Constrained Least Squares filtering improves upon other restoration techniques by incorporating a regularization term that explicitly measures image smoothness, typically using the Laplacian operator. This approach minimizes noise amplification at high frequencies by constraining the second derivative of the restored image,

Downloaded from www.pdf.tube

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

resulting in a significantly smoother and more stable reconstruction.

62. (C) Shearing
Shearing is an affine transformation that slants the shape of an image along either the horizontal or vertical axis. This distortion is mathematically achieved by introducing non-zero off-diagonal elements in the affine transformation matrix, which makes the new coordinate coordinates dependent on the values of the other spatial dimension.

63. (D) Saturation
Saturation is a fundamental property of color that defines its purity or dilution with white light. A fully saturated color is pure and contains no white light, whereas a desaturated color appears pale or pastel due to a high concentration of white light mixed with the dominant wavelength.

64. (C) It reduces computing overhead without inducing false colors.
Filtering only the intensity channel of the HSI model is computationally more efficient than processing all three RGB channels independently. Furthermore, because color information is isolated in the hue and saturation channels, smoothing only the intensity avoids the generation of false colors along spatial boundaries, preserving the overall color fidelity.

65. (B) They must be disjoint without overlapping active pixels.
The morphological Hit-or-Miss transform is a shape detection operator that requires two distinct structuring elements: one to fit the foreground and one to fit the background. To function correctly, these two structuring elements must be disjoint sets, meaning they share no common active pixels and do not overlap.

66. (D) Thinning
Morphological thickening is the dual operation of thinning, designed to grow the boundaries of foreground objects. Conceptually, thickening an object is mathematically equivalent to performing the thinning operation directly on the background of the set, highlighting the symmetrical relationship between foreground and background morphological processing techniques.

67. (A) Additive random noise
Gradient-based edge detectors rely on calculating first-order derivatives to locate rapid intensity changes. Because taking derivatives is a highpass operation that inherently amplifies high-frequency variations, these edge detection techniques are highly susceptible to additive random noise, which can produce numerous false edges if the image is not smoothed beforehand.

68. (C) Seed points and homogeneity criteria
Region growing is a segmentation technique that groups pixels into larger regions based on predefined rules. Its performance depends heavily on the selection of initial seed points, which represent the starting locations, and clear homogeneity criteria, which define the similarity threshold for appending neighboring pixels to the growing regions.

69. (A) They depend heavily on starting points and rotation.
A major limitation of using standard eight-directional Freeman chain codes for boundary representation is their high sensitivity to the choice of the starting pixel and the orientation of the object. To achieve robust shape recognition, the chain codes must be normalized to eliminate dependence on starting points and rotation.

NODIA

70. (C) P-3, Q-4, R-1, S-2
Image descriptors capture distinct geometric and statistical properties. Fourier descriptors reduce a boundary to a complex sequence, while shape numbers use the first difference of chain codes. Gray-level co-occurrence matrices model texture through spatial dependencies of pixel pairs, and Hu's moments provide descriptors invariant to scale, translation, and rotation.

71. (B) Lossy compression schemes
Psychovisual redundancy is based on the fact that the human eye does not perceive all visual information with equal sensitivity, such as high-frequency color variations. Lossy compression schemes exploit this biological limitation by permanently discarding psychovisually imperceptible data, allowing for significantly higher compression ratios than lossless compression techniques.

72. (B) 8×8
In the classic JPEG compression standard, the spatial image is partitioned into non-

gradient magnitude and direction in a local neighborhood, connecting adjacent pixels that share similar edge characteristics to form meaningful and coherent boundaries across the image.

116. (C) Between-class variance
Otsu's thresholding method determines the optimal global threshold by maximizing the between-class variance of the pixel intensities. This statistical approach separates the image into two classes, background and foreground, such that the difference between their average values is maximized, resulting in an optimal and automated segmentation result.

117. (A) Centroid-to-boundary distance versus angle
A spatial signature is a boundary descriptor that reduces a two-dimensional shape boundary into a one-dimensional function. It is commonly constructed by plotting the distance from the centroid of the shape to its boundary as a function of the angle, providing a representation invariant to spatial translation.

118. (D) Euler number
The Euler number is a topological descriptor that characterizes an object based on properties that remain invariant under rubber-sheet deformations. It is defined as the number of connected components minus the number of holes, providing a robust shape feature that does not change with scaling, rotation, or translation.

119. (B) Coding redundancy
Coding redundancy occurs when an image representation uses more bits than necessary to represent its symbols. Assigning fixed-length codes to all symbols, regardless of their probability of occurrence, fails to exploit the unequal statistical distribution of pixel intensities, leading to inefficient representation that can be compressed using variable-length codes.

120. (A) P-3, Q-1, R-4, S-2
Compression techniques employ distinct mechanisms to reduce data redundancy. Huffman coding uses variable-length codes based on symbol probabilities, while run-length encoding compresses consecutive identical symbols. DCT-based coding discards high-frequency spectral coefficients, and predictive coding achieves compression by encoding only the error between actual and estimated pixels.

121. (D) The level of fine detail expressed in line pairs per unit distance
Spatial resolution refers to the ability of an imaging system to resolve fine spatial detail, and is quantitatively measured in terms of line pairs per unit distance. It indicates the density of pixels or the minimum physical distance at which two distinct objects can be clearly distinguished.

122. (A) When sampling frequency is less than twice the highest spatial frequency
Aliasing occurs when the sampling frequency of an imaging system is less than twice the highest spatial frequency present in the continuous image. This violation of the Nyquist criterion causes high-frequency details to be mapped as artificial low frequencies, introducing severe visual distortions and artifacts.

123. (B) Euclidean distance
Euclidean distance is a geometric metric calculated as the straight-line distance between two points. Because it utilizes the square root of the sum of squared differences along all coordinate axes, it remains completely invariant to any angular rotation of the coordinate system, forming circular concentric distance boundaries.

124. (B) Compressing dynamic ranges with immense brightness changes
Logarithmic transformations are point processing operations used to map a wide dynamic range of low intensity values into a broader range of output levels, while compressing the higher intensity values. This makes them highly effective for displaying images with massive brightness variations, such as Fourier transform spectra.

125. (A) Probability Integral Transform
The mathematical derivation of continuous histogram equalization relies on the probability integral transform theorem. This theorem states that applying the cumulative distribution function of a continuous random variable as a transformation function yields a new random variable that is uniformly distributed, maximizing the image's overall contrast level.

126. (C) Exact spatial registration and alignment
Before performing digital image subtraction, it is absolutely essential to ensure that the source images are perfectly aligned and spatially

Click Here to Buy book on Amazon

83. (A) Dynamic range compression and contrast enhancement
Homomorphic filtering operates in the frequency domain to separate illumination and reflectance. By applying a filter that attenuates low frequencies while amplifying high frequencies, this technique simultaneously compresses the dynamic range of the slow-varying illumination and enhances the local contrast of the fast-varying reflectance details in the image.

84. (C) Electrical interference during capture
Periodic noise is a structured degradation that typically manifests as repetitive patterns across an image. The most common cause of this noise is electrical or electromagnetic interference during image acquisition, which introduces periodic sinusoidal signals into the imaging circuitry, creating distinct peaks in the frequency spectrum of the captured image.

85. (A) When the noise variance approaches zero
The geometric mean filter is a powerful restoration operator used to reduce noise while maintaining image details. Under the specific condition where the noise variance approaches zero, the mathematical formulation of the geometric mean filter simplifies directly to the standard inverse filter, which assumes a noise-free degradation process.

86. (D) Translation
Translation is a geometric spatial transformation that shifts coordinates by adding constant values. To express translation as a linear matrix multiplication alongside scaling, rotation, and shearing, coordinates must be represented in a homogeneous coordinate system, which adds an extra dimension and permits unified affine matrix operations.

87. (B) Blue-difference and Red-difference components
In the YCbCr color space, which is widely used in digital video systems, the Y component represents luminance. The Cb and Cr channels represent the chrominance components, specifically the blue-difference and red-difference signals, which carry the color information separately from the brightness details to optimize transmission bandwidth.

88. (C) Unpredictable and erroneous color hue shifts
Applying histogram equalization independently to the individual red, green, and blue color channels of an image alters their relative ratios. Because the color hue is determined by the specific balance between these channels, this independent processing inevitably results in severe, unpredictable, and erroneous color shifts in the final image.

89. (D) Dilation followed by Erosion
Morphological closing is a fundamental morphological operation defined as the dilation of an image by a structuring element, followed immediately by erosion using the same structuring element. This operation is highly effective for filling small holes, bridging narrow gaps, and smoothing the outer contours of foreground objects.

NODIA

90. (D) III and IV
Region filling uses dilation and complement operations, not erosion, to flood internal regions. Furthermore, a morphological skeleton cannot exactly reconstruct the original shape unless the radius of the maximal disk associated with each skeleton point is also stored, making statements three and four completely incorrect regarding advanced morphology.

91. (B) An intersecting point of sinusoidal curves
The Hough transform maps collinear points from the spatial xy-plane into the polar parameter space. Each spatial point is represented as a sinusoidal curve in the parameter space, and because the points are collinear, their corresponding sinusoidal curves intersect at a single coordinate point representing the line's parameters.

92. (B) Quadtree
Region splitting and merging segmentation frameworks utilize a hierarchical quadtree representation to organize image data. The quadtree structure recursively subdivides the image into four quadrants if a sub-region does not satisfy a predefined homogeneity predicate, and merges adjacent quadrants if their combined properties meet the homogeneity criteria.

93. (A) Cellular complexes
The minimum perimeter polygon technique is used to approximate the boundary of a digital shape. During this process, the boundary is

constrained within a channel formed by two concentric, nested polygons known as cellular complexes, which represent the inner and outer physical limits of the boundary representation.

94. (C) Ratios $\frac{m_{10}}{m_{00}}$ and $\frac{m_{01}}{m_{00}}$
The centroid of a spatial region is calculated using statistical moments. The coordinate coordinates of the centroid are mathematically defined as the ratios of the first-order moments to the zeroth-order moment, which represents the total area. This provides a robust, translation-invariant reference point for shape analysis.

95. (D) The difference of pixel and prediction
In predictive image coding, instead of storing the raw intensity values of each pixel, the encoder predicts the current pixel based on previous values and calculates the prediction error. Storing or transmitting only this prediction error, which is the difference of pixel and prediction, significantly reduces data redundancy.

96. (C) Self-similarity at varying scales
Fractal image compression is based on the concept of self-similarity, where parts of an image resemble other parts at different scales. By identifying and storing these affine transformations that map larger regions to smaller, self-similar blocks, this technique achieves exceptionally high compression ratios, particularly for natural, highly textured images.

97. (B) Perceive huge dynamic ranges by shifting its sensitivity curve
Brightness adaptation refers to the human visual system's capability to operate over an immense dynamic range of light intensities. Rather than responding to the entire range simultaneously, the eye shifts its overall sensitivity curve to adapt to a specific local average illumination level, optimizing visual detail discrimination.

98. (B) 8 bits
Quantizing an analog image into two hundred fifty-six discrete gray levels requires representing each pixel using eight bits. This is because two raised to the power of eight equals two hundred fifty-six, which is the minimum bit depth required to represent this specific number of intensity levels.

99. (A) The 4-neighborhood $N_4(p)$
For a pixel p at coordinates x, y, the set of pixels that are directly adjacent horizontally and vertically represents the four-neighborhood. This neighborhood consists of the four pixels located at coordinates x plus one, y; x minus one, y; x, y plus one; and x, y plus one.

100. (A) I, II and V
Point operations process pixels individually based on their original intensity, ignoring neighbor pixels. A negative image transformation is defined as L minus one minus r, and contrast stretching expands the dynamic range. However, power-law transformations are used for monitor gamma correction, and gray-level slicing is a spatial domain operation.

101. (A) A narrow, highly concentrated peak at any intensity level
Histogram equalization functions most effectively for images that possess a narrow, highly concentrated peak in their original histogram, representing a low-contrast image. By stretching this narrow peak across the entire available gray-scale range, the transformation maximizes contrast and reveals hidden details within the concentrated intensity levels.

102. (D) Addition
The fundamental arithmetic operation used in image averaging is addition. By adding together a sequence of multiple noisy images of the same stationary scene and then dividing the sum by the total number of images, the random, zero-mean noise cancels out, significantly enhancing the overall signal-to-noise ratio.

103. (B) It must equal 0.
A key defining characteristic of a Laplacian spatial filter mask is that the sum of all its coefficients must equal zero. This ensures that in areas of constant or flat intensity, the filter output is exactly zero, while highlighting regions of rapid intensity transitions, such as edges and details.

104. (C) Ideal lowpass filter
An ideal lowpass filter completely cuts off all frequency components beyond a specified cutoff radius while passing all frequencies within the radius without attenuation. This sharp step transition in the frequency domain acts like

Downloaded from www.pdf.tube

a sinc function in the spatial domain, causing pronounced ringing artifacts along sharp edges.

105. (D) Wavelet theory
The Haar transform is a discrete transform whose basis functions are derived from wavelet theory. It utilizes localized square waves of varying scales and positions, which allows it to decompose an image into multi-resolution representations that capture both spatial and frequency details simultaneously, making it highly effective for compression.

106. (A) Descending order of magnitude
In the Singular Value Decomposition of an image matrix, the diagonal matrix contains the singular values arranged in descending order of magnitude. These values represent the relative energy or variance associated with each corresponding singular vector, allowing for efficient low-rank approximations by retaining only the largest diagonal elements.

107. (B) Low frequencies
Homomorphic filtering separates the illumination and reflectance components of an image. Because illumination is assumed to vary slowly across the scene, it corresponds to the low-frequency range of the Fourier spectrum. Therefore, to suppress the illumination, the filter is designed to attenuate low-frequency components while preserving high frequencies.

108. (B) Salt-and-Pepper noise
Salt-and-pepper noise is a spatial noise model where pixels are randomly corrupted by extremely low and extremely high intensity values, appearing as black and white pixels. This impulse noise is typically caused by sensor transmission errors or faulty camera elements, and is best restored using non-linear median filtering.

109. (A) Direct Inverse filter
Direct inverse filtering attempts to restore a degraded image by dividing its Fourier transform by the degradation function. However, because the degradation function often has values close to zero at high frequencies, this division causes catastrophic noise amplification, rendering the restored image useless when additive noise is present.

110. (A) Both (A) and (R) are true and (R) is the correct explanation of (A)
Bilinear interpolation produces smoother transformed images than nearest-neighbor interpolation because it calculates the intensity of a remapped pixel based on a weighted average of the four surrounding discrete integer coordinates. This weighted average effectively reduces the blocky, jagged artifacts that typically occur with nearest-neighbor remapping.

111. (D) Cube
The RGB color model is mathematically represented as a three-dimensional geometric cube. In this coordinate system, the primary colors red, green, and blue are positioned along the three main axes, with black at the origin and white at the diagonally opposite corner, defining the full color gamut.

112. (C) Sharpening with localized color boundary shifts
Applying a Laplacian filter independently to the red, green, and blue components of an image will sharpen the spatial edges but can result in localized color boundary shifts. This occurs because the sharpening operation alters the intensity ratios between the channels along the edges, producing noticeable color artifacts.

113. (B) Morphological Opening
Applying an erosion operation followed immediately by a dilation operation using the same structuring element is defined as morphological opening. This fundamental morphological operator is primarily used to smooth object contours, eliminate thin protrusions, and remove small foreground noise details from binary or grayscale images.

114. (D) The Eroded image
The morphological boundary extraction algorithm calculates the difference between the original binary image and its eroded version. Because erosion shrinks the foreground object by removing its outer boundary pixels, subtracting the eroded image from the original leaves behind only the single-pixel-wide outer contour of the object.

NODIA

115. (A) Local edge following
Local edge following is a boundary extraction technique that links edge pixels into continuous contours. It achieves this by analyzing the

137. (D) $(A \ominus B_1) \cap (A^c \ominus B_2)$
The morphological Hit-or-Miss transform identifies specific shapes within binary images by utilizing a pair of disjoint structuring elements. The first structuring element detects the foreground shape using erosion, while the second structuring element detects the background using erosion on the complement. The intersection of these two erosion operations yields only the exact matching target locations.

138. (A) Sharp intensity transitions
The morphological gradient of a grayscale image is computed by subtracting the eroded version of the image from its dilated version. Because dilation expands bright regions and erosion shrinks them, subtraction of the two results highlights boundaries where gray levels change rapidly. This operation effectively isolates sharp intensity transitions, representing the physical edges of structures.

139. (C) 8
In spatial filtering, detecting an isolated point requires a mask whose coefficients sum to zero, ensuring a constant area produces no response. If the eight surrounding coefficients of a three-by-three mask are set to minus one, their sum is minus eight. Consequently, the center coefficient must be eight so that the overall mask sum equals zero.

140. (B) III
Otsu's thresholding method is an unsupervised, automatic technique that calculates the optimal threshold directly from the image histogram. It operates by maximizing the between-class variance of the gray-level classes without requiring any prior geometric or structural knowledge of the target objects. The other assertions accurately describe global, local, and adaptive thresholding methods.

141. (A) Utilizing the first difference of the chain code
The Freeman chain code represents a boundary using directional vectors. To make this representation invariant to rotation, the first difference of the chain code is calculated. This difference measures the change in direction between adjacent boundary segments rather than absolute directions. The resulting sequence remains constant regardless of the orientation of the boundary on the grid.

142. (C) The chain code representation length
Shape numbers are closed, normalized chain codes used for shape description. The order of a shape number is defined as the number of digits in its representation, which corresponds directly to the perimeter length of the boundary. For any closed boundary represented on a square grid, this order must always be a positive even integer.

143. (D) The fidelity of the reconstructed image
Mean Square Error and Peak Signal-to-Noise Ratio are standard objective metrics used to quantify the differences between an original image and its reconstructed version after compression. These metrics measure reconstruction fidelity by calculating pixel-by-pixel intensity deviations, allowing researchers to evaluate how closely the decompressed image matches the original uncompressed source data.

144. (C) Fractal Image Compression
Fractal image compression exploits self-similarity in images by partitioning them into blocks and finding affine transformations that map larger regions to smaller ones. These contractive mappings form an Iterated Function System. During decompression, the system iteratively applies these mathematical transforms to any initial image, which eventually converges to reconstruct the original visual scene.

145. (B) Blocky pixelation artifacts appear
Reducing spatial resolution decreases the total number of pixels available to represent an image. When such an image is displayed at its original physical size, each individual pixel must be enlarged to span a larger area. This expansion makes the discrete boundaries between pixels clearly visible, producing a characteristic blocky, pixelated visual appearance.

146. (D) False contouring
Gray-level quantization defines the continuous amplitude values using a finite set of discrete levels. When too few bits are allocated for quantization, the transitions between smooth, gradual intensity variations become abrupt and coarse. This coarseness manifests visually as unnatural, distinct boundaries or bands across the image, a degradation phenomenon known as false contouring.

Click Here to Buy book on Flipkart

registered. Any minor spatial mismatch or registration error will result in severe motion artifacts and false differences, rendering the subtracted image medically or analytically useless.

127. (D) It replaces pixels with the neighborhood median, removing impulse noise while preserving edges.
A median filter is a non-linear spatial operator that replaces the center pixel of a window with the median value of all pixels in that neighborhood. This process is exceptionally effective at removing salt-and-pepper impulse noise while preserving sharp structural edges, unlike linear filters that blur details.

128. (C) The dimensions must be integer powers of 2.
The Fast Fourier Transform algorithm achieves its high efficiency by recursively decomposing the discrete Fourier transform calculations. To perform this divide-and-conquer processing optimally, the spatial dimensions of the input image must be integer powers of two, which often requires padding the image borders with zeros.

129. (B) Both spatial and frequency domains
Unlike the Fourier transform, which utilizes infinitely extending sinusoidal basis functions, the Haar transform uses localized step functions. This mathematical property allows the Haar transform to decompose an image into basis functions that are highly localized in both the spatial and frequency domains, providing excellent multi-resolution representation.

130. (B) I and II
Unitary transforms possess distinct mathematical properties. The Karhunen-Loève transform is data-dependent and requires computing the image covariance matrix, while Singular Value Decomposition achieves compression by retaining only the largest singular values. However, the basis functions of the Karhunen-Loève transform are not fixed sinusoids but are data-dependent eigenvectors.

131. (A) Applying an exponential transformation
Homomorphic filtering begins by taking the natural logarithm of the image to convert the multiplicative illumination and reflectance components into an additive relationship. After applying a frequency domain filter, the final mathematical step requires taking the exponential of the processed image to restore the original multiplicative dynamic range.

132. (C) Estimation by image observation
Estimating the degradation function by image observation involves analyzing a small, high-contrast subimage within the degraded image itself. By examining areas with simple, known structures, such as a sharp edge, researchers can estimate the blur characteristics and construct a mathematical model of the degradation function for restoration.

133. (A) Avoiding division by near-zero degradation values using regularization
Constrained Least Squares filtering addresses the vulnerability of the basic inverse filter by incorporating a regularization term. This term prevents catastrophic noise amplification by avoiding direct division by near-zero values of the degradation function, constraining the high-frequency smoothness of the restored image to achieve a stable reconstruction.

134. (D) Inverse mapping and interpolation
During geometric spatial transformations, inverse mapping is utilized to determine which source pixel corresponds to each coordinate in the target grid. Because the mapped coordinates rarely align perfectly with discrete pixel locations, intensity interpolation is required to calculate the final pixel values, preventing holes and overlapping artifacts.

135. (B) Pure Black
The CMY color model is based on subtractive color mixing, where pigments absorb specific wavelengths of light. When cyan, magenta, and yellow pigments are mixed together at their maximum intensities, they theoretically absorb all visible light wavelengths, resulting in the perception of pure black by the human eye.

136. (C) YCbCr
The YCbCr color space separates luminance, represented by Y, from chrominance, represented by blue-difference Cb and red-difference Cr. Human vision is far more sensitive to structural luminance than to color details. Separating these components allows compression systems like JPEG to sub-sample the chrominance channels, dramatically reducing data storage while preserving perceived visual quality.

Downloaded from www.pdf.tube

overlapping blocks of eight-by-eight pixels before applying the Discrete Cosine Transform. This block size provides an optimal trade-off between computational complexity and energy compaction, minimizing the mathematical overhead of transforming large matrix areas during encoding.

73. (D) Lateral inhibition within the retina
The perception of Mach bands is caused by lateral inhibition, a physiological process where stimulated retinal receptors inhibit the activity of adjacent receptors. This neural interaction enhances the perceived contrast at boundaries between regions of different intensities, making the edges appear sharper and creating the illusion of bright and dark bands.

74. (A) 0.042 mm
To find the spatial distance between adjacent pixels at six hundred dots per inch, we divide twenty-five point four millimeters by six hundred. This calculation yields a pixel spacing of approximately zero point zero four two millimeters, representing the physical resolution of the digital sensor or print output.

75. (B) The City-block distance between (x, y) and $(x+1, y+1)$ is 1.
The city-block distance metric calculates path lengths using only horizontal and vertical steps. For diagonal neighboring pixels located at coordinates x, y and x plus one, y plus one, the city-block distance is computed as one plus one, which equals two. Thus, stating this distance is one is mathematically incorrect.

76. (B) $r_1 = r_2$ and $s_1 = 0, s_2 = L - 1$
In contrast stretching, a binary thresholding effect is achieved when the intermediate control points align vertically such that r-one equals r-two, with s-one set to zero and s-two set to the maximum intensity. This configuration maps all values below the threshold to zero and all values above to maximum.

77. (A) Only the center pixel of the window
Local histogram equalization is implemented by moving a small neighborhood window across the image pixel by pixel. At each position, the local histogram of the pixels within the window is calculated, and the resulting equalization transformation is applied to update only the intensity value of the center pixel of the window.

78. (C) Logical AND
The logical AND operator is the fundamental arithmetic-logic operation used for region-of-interest masking. By performing a bitwise AND operation between the input image and a binary mask where the desired region contains ones and other areas contain zeros, the background is eliminated while the specified region is perfectly preserved.

79. (D) Subtracting a blurred version of the image from the original
Unsharp masking is a classic spatial domain sharpening technique. The unsharp mask itself is generated by subtracting a blurred, lowpass filtered version of the image from the original image. Adding this high-frequency difference mask back to the original image enhances the edges and fine details, creating a sharper visual appearance.

80. (B) I and II
The two-dimensional Discrete Fourier Transform possesses key mathematical properties. For real-valued images, the spectrum displays conjugate symmetry. Furthermore, multiplication of two signals in the spatial domain is equivalent to their convolution in the frequency domain, whereas low-frequency components, not high-frequency ones, correspond to smooth intensity transitions.

NODIA

81. (B) Odd symmetry
The discrete sine transform is a mathematical derivative of the Fourier transform whose basis functions consist entirely of sine waves. Because sine waves are asymmetric, this transform is uniquely suited for processing and compressing digital signals or images that possess odd symmetry about their spatial boundaries or origins.

82. (D) Karhunen-Loève Transform
The Karhunen-Loève transform is a statistical transform that calculates eigenvectors directly from the image covariance matrix. This mathematical approach aligns the transform's basis functions with the directions of maximum variance in the data, resulting in optimal energy compaction and complete decorrelation of the processed image components.

147. (A) Diagonally adjacent
In digital image relations, two pixels that touch only at a single corner point do not share any common horizontal or vertical edges. Such pixels are classified as diagonally adjacent. This geometric relationship forms part of the eight-neighborhood configuration but is excluded from the stricter four-neighborhood system, which requires sharing a common linear boundary.

148. (C) Image negative
The image negative transformation is a spatial point operation that reverses the intensity levels of a digital image. In a system with a maximum gray level of L, each input pixel intensity r is mapped to L minus one minus r. This processing is highly valuable for analyzing fine structures in medical X-rays.

149. (A) It maps the input histogram to a specified target distribution.
While histogram equalization automatically stretches an image's gray levels to approximate a uniform distribution, histogram matching, also known as histogram specification, provides direct control. This advanced process allows a user to specify a particular target probability density function, mapping the input intensities to match the shape of that customized reference distribution.

150. (D) I, II and V
Image addition facilitates watermarking by blending pixel intensities. Averaging multiple noisy images reduces random noise, provided that the noise is uncorrelated and has a zero mean. Pixel-by-pixel multiplication is used to apply binary masks to isolate regions. However, subtraction does not require prior equalization, and bit-plane slicing is not a division operation.

151. (B) It has higher computational complexity due to sorting.
Unlike linear mean filters that only perform simple arithmetic addition and division, the median filter is a non-linear spatial filter. It requires sorting all the pixel values within a local neighborhood window to find the middle value. This sorting process significantly increases computational complexity and execution time, particularly for larger neighborhood window sizes.

152. (C) A Gaussian function
A fundamental mathematical property of the Fourier transform is that the transform of a Gaussian function is itself a Gaussian function. When a Gaussian lowpass filter is defined in the frequency domain, its spatial representation, obtained via the inverse Fourier transform, remains a Gaussian function, avoiding the spatial ringing artifacts caused by sinc functions.

153. (D) Mirroring boundaries to enforce even symmetry
The Discrete Fourier Transform assumes periodic boundary conditions, which can introduce artificial high-frequency boundary discontinuities. In contrast, the Discrete Cosine Transform implicitly mirrors the boundaries of image blocks to enforce even symmetry. This mirroring prevents sharp step discontinuities at block boundaries, minimizing blocky edge artifacts in compressed images like JPEG.

154. (A) Covariance matrix
The Karhunen-Loève Transform is a data-dependent transformation designed to decorrelate image features. To construct its basis functions, the algorithm computes the covariance matrix of the input dataset. The eigenvectors of this covariance matrix represent the principal components, which serve as the transform coefficients, maximizing variance along the newly aligned coordinate axes.

155. (B) Uneven contrast from illumination gradients
Homomorphic filtering separates an image into illumination and reflectance components by applying a logarithm. Because illumination changes slowly across space, it dominates the low frequencies, whereas reflectance dominates the high frequencies. By suppressing low frequencies and boosting high frequencies, this filter reduces uneven illumination gradients, thereby restoring consistent visual contrast across the scene.

156. (B) Impulse PDF
An impulse probability density function models salt-and-pepper noise, where pixels randomly take on extreme minimum or maximum values. When a sensor is badly calibrated and contains unreactive pixels that cannot register light, these defective pixels appear as permanent black points. This physical degradation is accurately represented mathematically by the unipolar impulse noise distribution.

Click Here to Buy book on Amazon

frequency coefficients can vary by several orders of magnitude, making low-amplitude details visible alongside high-intensity peaks.

197. (A) Histogram equalization
Histogram equalization is an intensity mapping technique that utilizes the cumulative distribution function of an image. By spreading out highly concentrated pixel intensities across the entire available gray-level range, it transforms the input histogram into an approximately uniform distribution, thereby maximizing the global contrast and highlighting the subtle structural details.

198. (D) Subtraction
Mask mode radiography is a medical imaging technique used to visualize blood vessels. A mask image is captured before injecting a contrast medium, and subsequent images are taken afterward. Subtracting the mask from these active images removes static background structures like bones and tissue, leaving only the blood vessels clearly visible.

199. (B) It removes impulse noise while preserving sharp edges.
The median filter is a non-linear spatial filter that replaces each pixel value with the median of its neighborhood. Because it does not average intensities, it is exceptionally effective at removing high-amplitude impulse noise, such as salt-and-pepper noise, without blurring sharp edges, unlike linear mean filters that smooth out structural boundaries.

200. (C) Significant reduction of spatial ringing artifacts
An ideal lowpass filter has a sharp cutoff that acts as a step function in the frequency domain, causing prominent ringing artifacts in the spatial domain. The Butterworth filter features a smooth, gradual transition between the passband and the stopband. This continuous roll-off significantly reduces spatial ringing, resulting in visually superior blurred images.

201. (D) Discrete Wavelet Transform (DWT)
The Discrete Wavelet Transform analyzes images using localized, oscillating basis functions called wavelets, which vary in both scale and translation. This approach provides multi-resolution analysis by decomposing the image into spatial frequencies and localized temporal features, unlike the Fourier transform, which relies on sinusoids that span the entire spatial domain.

NODIA

202. (A) The inverse of the transform matrix equals its transpose.
A discrete transform matrix is defined as orthogonal if its row and column vectors form an orthonormal set. Mathematically, this property dictates that multiplying the matrix by its transpose yields the identity matrix. Consequently, the inverse of an orthogonal transform matrix is simply its transpose, which greatly simplifies the calculation of inverse transforms.

203. (B) Slowly varying low spatial frequencies
According to the illumination-reflectance model, an image is the product of the light illuminating the scene and the reflectance of the objects. The illumination component represents the light source and tends to vary slowly across spatial coordinates. This slow variation means illumination is characterized primarily by low spatial frequencies in the frequency domain.

204. (B) Uniform PDF
A uniform probability density function models noise where the gray-level values are distributed with equal probability over a specified, bounded interval. The probability density remains constant between the lower parameter limit and the upper parameter limit, and is zero elsewhere. This distribution is commonly used to model quantization noise in digital systems.

205. (A) Direct Inverse filter
The direct inverse filter recovers an image by dividing the degraded spectrum by the blur transfer function. In the absence of additive noise, this mathematical division reconstructs the original scene perfectly. However, if any noise were present, this method would fail catastrophically by amplifying noise at frequencies where the blur function is close to zero.

206. (C) Gray-level interpolation
Geometric transformations map pixels to new coordinate locations, which often result in fractional coordinates that do not align with the discrete grid. To determine the appropriate intensity values for these non-integer coordinates, spatial interpolation is required. This process

167. (B) The source entropy
In information theory, the source entropy establishes the absolute mathematical lower bound on the average number of bits required to represent each symbol in a message without information loss. Calculated using the probability distribution of the source alphabet, entropy represents the fundamental limit of data compression for any lossless encoding algorithm.

168. (C) LZW Coding
Lempel-Ziv-Welch coding is a dictionary-based lossless compression algorithm that operates dynamically. As the encoder reads the input data stream, it registers new sequences into a dictionary on the fly. Because the decoder reconstructs the exact same dictionary using the identical logical rules, the dictionary does not need to be transmitted with the compressed data.

169. (D) Cones
The human retina contains two primary types of photoreceptor cells, which are rods and cones. Under high-illumination or photopic conditions, the cones are responsible for visual perception. Cones are highly concentrated in the central fovea and are sensitive to different wavelengths of light, enabling detailed spatial resolution and full color perception.

170. (A) P-1, Q-4, R-3, S-2
Digitizing the spatial coordinates of a continuous image is defined as sampling, while digitizing the continuous amplitude values is called quantization. Spatial resolution measures the smallest discernible visual detail. When a continuous signal is under-sampled, high-frequency components manifest as lower frequencies, a distorting phenomenon known as spatial aliasing.

171. (B) Geodesic distance
The geodesic distance between two active pixels in a digital image is defined as the length of the shortest path connecting them that remains entirely within a specified foreground subset. Unlike standard Euclidean distance, geodesic distance accounts for structural obstacles by prohibiting the path from traversing background pixels, reflecting connectivity constraints.

172. (B) Thresholding
Thresholding is a fundamental intensity transformation used to segment objects from their background. It maps all input pixels below a specified threshold intensity value to zero, representing black, and maps all pixels equal to or above that threshold to the maximum intensity value, producing a simplified binary representation of the scene.

173. (A) Enhanced contrast with high quantization noise
When an image contains only a very narrow range of dark intensities, applying global histogram equalization forces these few occupied levels to map to widely spaced output levels. While this mapping dramatically enhances the contrast of the dark features, it also amplifies the background noise and creates prominent, blocky quantization artifacts.

174. (C) AND
In binary image processing, pixels are represented as Boolean states, where foreground pixels are true and background pixels are false. The set intersection of two binary images identifies the spatial locations where both images possess foreground pixels. This logical operation is mathematically implemented using the logical bitwise AND operator.

175. (B) 2
The Sobel operator is used to approximate the spatial gradient of an image. To compute the full gradient vector magnitude, two orthogonal convolution masks are required. One mask calculates the horizontal derivative, while the second mask calculates the vertical derivative. These two components are then combined mathematically to determine the gradient magnitude.

176. (C) Translation theorem
The translation theorem of the Fourier transform states that multiplying a spatial function by a complex exponential shifts its spectrum in the frequency domain. Conversely, shifting the spatial coordinates of an image introduces a phase shift in its discrete Fourier transform without altering the magnitude of the frequency spectrum.

Downloaded from www.pdf.tube

217. (D) Simultaneous contrast
Simultaneous contrast is a visual perception phenomenon where the perceived brightness of an object is influenced by the intensity of its surrounding background. A gray square will appear lighter when placed against a dark background than when placed against a light background, because the human visual system processes contrast relative to the immediate environment.

218. (A) $(M-1, N-1)$
In standard digital image processing, coordinate systems typically use zero-based indexing, where the top-left pixel of an image is designated as coordinate zero, zero. For an image with M rows and N columns, the row indices range from zero to M minus one, and column indices range from zero to N minus one, placing the bottom-right pixel.

219. (B) Transitivity, reflexivity, and symmetry
For an adjacency or connectivity metric to establish an equivalence relation over a set of pixels, it must satisfy three mathematical properties. These properties are reflexivity, meaning a pixel is connected to itself; symmetry, meaning if p is connected to q, then q is connected to p; and transitivity, establishing connected paths.

220. (B) P-2, Q-1, R-4, S-3
The negative transformation reverses intensity levels, while the log transformation compresses the dynamic range of high values. The power-law gamma transformation maps curves using an exponent, and contrast stretching applies piecewise-linear functions to expand the range of selected intensities. These transformations are fundamental tools for spatial domain image enhancement.

221. (A) Adaptive (local) histogram equalization
Adaptive histogram equalization enhances image contrast locally by calculating the cumulative distribution function within a small, sliding neighborhood window. Unlike global equalization, which applies a single transformation to the entire image, this localized approach adapts to the local contrast variations, successfully revealing fine details in both very dark and very bright regions.

NODIA

222. (C) Base-2 binary numeral system
Bit-plane slicing relies on representing the intensity of each pixel using the base-two binary numeral system. In an eight-bit image, each pixel's value is composed of eight binary digits. Slicing decomposes the image into eight binary planes, where each plane represents the spatial distribution of a specific bit position, highlighting structural information.

223. (C) The sharp frequency cutoff discontinuity
Mathematically, 2D spatial convolution involves sliding a kernel across an image. For asymmetric kernels, convolution requires rotating the kernel by one hundred eighty degrees before performing the sum of products. This specific rotation distinguishes convolution from cross-correlation, which performs the exact same sliding summation but without rotating the filter kernel.

224. (C) The sharp frequency cutoff discontinuity
Ringing artifacts in the spatial domain are caused by the sharp, discontinuous cutoff of an ideal lowpass filter in the frequency domain. This step-like discontinuity transforms into a sinc-like function in the spatial domain. The oscillating lobes of the sinc function manifest visually as concentric ripples or halos around sharp edges in the filtered image.

225. (B) It operates with real numbers and packs energy efficiently.
The Discrete Cosine Transform is highly preferred for image compression because it operates entirely with real numbers, avoiding complex imaginary arithmetic. Additionally, it possesses an exceptional energy compaction property, concentrating the vast majority of the image's visual information into a few low-frequency coefficients, which maximizes overall compression efficiency.

226. (D) By reconstructing using only the largest singular values.
Singular Value Decomposition decomposes an image matrix into singular values and corresponding singular vectors. Because these values are ordered by magnitude, the most significant structural details are captured by the largest singular values. Dropping the smaller singular values allows for highly efficient data reduction while maintaining the overall visual quality of the image.

structuring element without changing overall shape size.

187. (B) It uses smoothing, non-maximum suppression, and hysteresis thresholding.
The Canny edge detector is highly effective because it employs a multi-stage approach. First, it applies Gaussian smoothing to reduce noise. It then computes gradient directions and performs non-maximum suppression to thin the detected boundaries. Finally, it uses hysteresis thresholding with dual thresholds to preserve weak but connected edges while suppressing spurious noise.

188. (B) The homogeneity predicate $P(R_i)$ is TRUE for that quadrant.
In region splitting and merging, an image is recursively subdivided into quadrants. This splitting process continues as long as a quadrant fails to satisfy a predefined homogeneity predicate. The subdivision of a specific sub-region stops only when the homogeneity predicate evaluates to true, indicating that all pixels within that quadrant share uniform features.

189. (A) Spatial Signatures
A spatial signature is a one-dimensional functional representation of a two-dimensional boundary. It is generated by calculating the distance from the centroid of an object to its boundary points as a function of angle. This approach simplifies shape analysis by converting complex boundary coordinates into a singular, easier-to-analyze waveform.

190. (C) III, I, IV, II
The standard JPEG image compression pipeline begins by dividing the input image into discrete eight-by-eight pixel blocks. The discrete cosine transform is then applied to each block to convert spatial intensities into frequency coefficients. Next, these coefficients are quantized to reduce precision. Finally, entropy coding via Huffman coding compressed the remaining non-zero coefficients.

191. (D) The minimum bits per pixel needed for lossless representation.
In information theory, the entropy of an image measures the average information content or uncertainty present in the pixel intensity distribution. Mathematically, this value defines the theoretical minimum number of bits per pixel required to encode the image losslessly, serving as a benchmark for evaluating the efficiency of compression algorithms.

192. (C) MPEG
The MPEG standard is designed for video compression, where adjacent frames exhibit high similarity over time. To eliminate this temporal redundancy, MPEG utilizes motion compensation algorithms. These algorithms estimate the displacement of objects between frames, transmitting only the residual differences and motion vectors, which dramatically reduces the overall transmitted data rate.

193. (B) Purkinje shift
The Purkinje shift describes the change in spectral sensitivity of the human visual system during dark adaptation. In bright light, cone-based photopic vision peaks near yellow-green wavelengths. As illumination drops and rod-based scotopic vision takes over, peak sensitivity shifts toward shorter blue-green wavelengths, making blue objects appear brighter than red ones in low light.

194. (C) 1 Megabyte (MB)
An uncompressed digital image with a spatial resolution of 1024 by 1024 pixels contains exactly one million forty-eight thousand five hundred seventy-six individual pixels. With an eight-bit gray-level depth, each pixel requires exactly one byte of storage. Therefore, the total memory needed is exactly one megabyte, which equals the total pixel count.

195. (A) A path of adjacent pixels in V connects p and q.
For a continuous path to exist between two pixels, there must be a sequence of adjacent pixels starting at the first pixel and ending at the second. Every pixel along this path must belong to a specified set of intensities, ensuring physical connectivity under the chosen adjacency definition, such as four-adjacency or eight-adjacency.

196. (C) Fourier spectrums containing very high dynamic range peaks
The log transformation maps a narrow range of low-intensity input values into a wider range of output levels, while compressing higher values. This logarithmic scaling is highly effective for displaying the Fourier spectrum, where

Click Here to Buy book on Flipkart

157. (A) The Inverse filter
The Wiener filter is formulated to balance image restoration and noise amplification by incorporating the noise-to-signal power ratio. When the noise variance is zero, this ratio becomes zero. The Wiener filter mathematical equation then reduces directly to the inverse filter, which simply divides the degraded image spectrum by the spatial degradation function.

158. (C) 3×3
To perform two-dimensional affine transformations like translation, scaling, and rotation using unified matrix multiplication, homogeneous coordinates are introduced. This method adds a dummy coordinate to the spatial vectors, expressing them in three dimensions. Consequently, the transformation matrix must be a three-by-three matrix to accommodate translation offsets along with linear operations.

159. (D) Red, Green, Blue
The additive color theory of light states that different colors are perceived by mixing varying intensities of three primary wavelengths. These primary components are red, green, and blue. Combining these three additive primaries at maximum intensity yields white light, which forms the basis for color capture and display technologies like digital monitors.

160. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Pseudocolor processing assigns colors to gray levels to enhance visual analysis. While the human eye can distinguish only a few dozen gray levels under steady viewing conditions, it can detect thousands of distinct colors. Translating gray intensities into colors exploits this physiological capability, dramatically improving the visibility and interpretation of subtle features in medical scans.

161. (B) Erosion
Morphological erosion is mathematically defined as the locus of points where the structuring element fits entirely inside the input set. Conceptually, this operation can be formulated as the intersection of the input image with its translated counterparts. This process shrinks the boundaries of foreground objects, effectively revealing the core structural geometry of the shape.

162. (D) The Closed image
The morphological bottom-hat transform is a specialized operation used to isolate dark details against a lighter background. It is computed by subtracting the original input image from its morphologically closed counterpart. Because morphological closing fills in small dark holes and gaps, this subtraction isolates the filled dark structures, highlighting them for extraction.

163. (A) Topographic surface elevations
The watershed segmentation algorithm is inspired by mathematical geomorphology. It interprets the spatial intensity values of an image as a physical topographic surface, where gray levels correspond to elevations. In this metaphor, local minima act as catchments that fill with water, and the boundaries between different catchment basins form the final segmentation lines.

164. (C) They are sensitive to noise and seed point placement.
Region growing is a spatial segmentation technique that groups pixels into larger regions based on predefined similarity criteria. A primary disadvantage of this method is its high sensitivity to noise and initial seed point placement. Noisy pixels can cause the growing process to stop prematurely or leak across thin boundaries into unrelated regions.

165. (A) Minimizing line segments while maintaining boundary shape
A polygonal approximation represents a digital boundary using a sequence of straight-line segments. The primary goal of this technique is to simplify the boundary representation by minimizing the number of vertices and line segments. This reduction must be achieved while preserving the overall structural shape of the object within a specified error tolerance.

166. (D) Fourier descriptors
Fourier descriptors represent a closed boundary by treating its coordinate sequence as a periodic complex signal and computing its discrete Fourier transform. This spectral expansion provides invariance to scale, translation, and rotation through simple normalization of the resulting coefficients. These descriptors are highly efficient for summarizing and comparing global shape characteristics.

NODIA

estimates the new intensities using the values of nearby, integer-positioned pixels.

207. (D) Hue, Saturation, Intensity (HSI)
The HSI color model is designed to align with human visual perception. It decouples intensity, representing brightness, from chromatic information, which is described by hue and saturation. This representation directly matches how humans describe colors, distinguishing a color by its pure wavelength, its purity or dilution with white, and its overall brightness.

208. (C) The specific intensity interval of the pixels
In pseudocolor processing using intensity slicing, the grayscale range is divided into discrete intervals by slicing planes. Each pixel is assigned a specific color based on the intensity interval into which its gray value falls. This mapping converts continuous gray tones into distinct color bands, helping observers differentiate subtle structures based on intensity.

209. (B) It must have a defined origin and shape (e.g., cross, square).
A structuring element in morphological image processing is a small sub-image or mask used to probe the input shape. To perform operations like dilation or erosion, the structuring element must have a clearly defined coordinate origin and geometric shape. The size and shape of this element directly control the morphological features extracted.

210. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
The morphological gradient is a powerful tool for edge extraction in grayscale images. It is calculated by subtracting the eroded version of the image from its dilated version. Because dilation expands bright boundaries and erosion contracts them, their difference isolates areas of rapid intensity change, producing a band that represents the outer boundaries of objects.

211. (A) Unbroken straight lines
The standard Hough transform is a parameter space mapping technique used to detect geometric primitives. In its primary implementation, it maps collinear points in an image space to intersecting sinusoidal curves in a polar coordinate parameter space. This mapping allows the algorithm to identify and extract unbroken straight lines, even in noisy environments.

212. (C) Within-class variance
Otsu's thresholding method calculates an optimal threshold to separate pixels into background and foreground classes. The algorithm operates by maximizing the between-class variance, which is mathematically equivalent to minimizing the within-class variance. Minimizing this variance ensures that both classes are as homogeneous as possible, leading to a highly accurate binary segmentation.

213. (A) Freeman chain codes
Freeman chain codes are used to represent a boundary as a sequence of connected straight-line segments of specified length and direction. The direction of each segment is mapped to a set of predefined angles on a grid, representing either four-connectivity or eight-connectivity, allowing the perimeter of an object to be stored compactly.

214. (D) They remain constant under non-tearing deformations.
Topological descriptors, such as the Euler number, measure global structural properties of a region. These descriptors remain strictly invariant under rubber-sheet deformations, which include stretching, rotation, and scaling, provided the image is not torn or joined. This robustness makes topological features highly useful for describing shapes regardless of their geometric distortions.

215. (B) Correlation and similarity between neighboring pixel values
Spatial redundancy arises because pixels in a digital image are highly correlated with their neighbors. In most natural images, adjacent pixels represent the same object or background and thus share very similar color and intensity values. This spatial correlation means that individual pixel values can be predicted from surrounding pixels, allowing for compression.

NODIA

216. (C) JPEG
The original JPEG standard is a widely used lossy compression method designed for continuous-tone still images. It operates by partitioning the image into eight-by-eight blocks, transforming them using the discrete cosine transform, quantizing the resulting coefficients to eliminate high-frequency details, and finally encoding the compressed data stream using Huffman or arithmetic coding.

237. (A) A rubber band snapping tight around obstacles
The Minimum Perimeter Polygon method is a geometric boundary approximation technique. It conceptually simulates a rubber band placed inside a hollow channel representing the boundary. When the rubber band is allowed to contract, it snaps tight against the inner and outer vertices of the channel, forming a simplified polygon that represents the shape.

238. (C) Image texture
Co-occurrence matrices are a powerful statistical tool used for texture analysis. They analyze the spatial relationships of gray levels by counting how often pairs of pixels with specific intensities occur at a defined spatial distance and orientation. This representation allows the extraction of texture features like contrast, energy, and entropy.

239. (D) Mean Square Error (MSE)
Mean Square Error is a standard objective metric used to measure reconstruction quality. It calculates the average of the squared differences between the intensity values of the original pixels and their corresponding reconstructed pixels. A lower error value indicates that the decompressed image is physically closer to the original source.

240. (C) II, I, III, IV
Lossless predictive coding begins by predicting the intensity of a target pixel using the values of its previously processed neighbors. The difference between the actual value and this prediction is calculated to find the prediction error. This error is then encoded using variable-length coding and transmitted, minimizing spatial redundancy.

241. (B) The density of the sensor photosites
The fundamental limit of spatial resolution in an imaging system is determined by the physical spacing and density of the photosites on the sensor array. A higher density allows the sensor to capture finer spatial details, whereas a sparse array results in under-sampling and can introduce spatial aliasing artifacts.

242. (D) It must be strictly band-limited.
Shannon's sampling theorem dictates that a continuous signal can be perfectly reconstructed from its discrete samples only if the signal is strictly band-limited. This condition requires that the signal contains no frequency components higher than a maximum frequency, allowing a sampling rate at least twice this maximum frequency.

243. (A) Their intersection contains no pixels of the set V.
Two pixels are defined as m-adjacent if they are diagonally adjacent and their respective four-neighborhoods do not share any pixels belonging to the active set of intensities. This restriction prevents the formation of multiple parallel paths, simplifying connectivity analysis by ensuring that only unique paths are established across the grid.

244. (C) A wider range of brighter output values
A power-law transformation with a gamma exponent less than one produces a curve that is steep at low input values. This characteristics expands the narrow, dark regions of the input scale into a wider, brighter range of output intensities. Consequently, this transformation enhances detail visibility in shadowed areas of an image.

245. (A) Discrete gray levels cannot be fractionally divided.
In a discrete image, pixel intensities are represented by integer values. The histogram equalization mapping is based on the cumulative distribution function, which assumes continuous variables. Because discrete gray levels cannot be fractionally divided or split, the resulting histogram can only approximate, but rarely achieve, a perfectly flat, uniform distribution.

246. (D) Masking out arbitrary regions of an image
Image multiplication is a pixel-by-pixel arithmetic operation. It is commonly used in image processing to apply binary masks to an image. In a binary mask, regions of interest have a value of one, while background areas are zero. Multiplying the image by this mask preserves the target regions and eliminates the background.

247. (B) It is highly sensitive to high-frequency noise.
The Laplacian is a second-order derivative operator, which makes it highly sensitive to rapid intensity changes. In a noisy image, even minor high-frequency noise spikes produce extremely large derivative values. This sensitivity causes the Laplacian to detect false edges throughout the image, making it unsuitable for direct edge detection without prior smoothing.

Downloaded from www.pdf.tube

227. (A) Homomorphic filtering
Homomorphic filtering uses the illumination-reflectance model to enhance images affected by uneven lighting. By applying a logarithmic transform, it separates the low-frequency illumination from the high-frequency reflectance. Spatial filtering then attenuates the low-frequency illumination components, reducing shadows, while simultaneously amplifying the high-frequency reflectance components, which sharpens fine surface details.

228. (C) Poisson PDF
Poisson noise, also known as shot noise, is a type of electronic noise that occurs in low-light imaging conditions. It arises from the statistical, quantum fluctuations in the arrival of individual photons at the sensor. This physical process is mathematically modeled using a Poisson distribution, where the variance is equal to the mean signal level.

229. (A) It restores the image except at degradation zero-crossings.
In the absence of additive noise, the inverse filter can theoretically restore a blurred image perfectly. However, the degradation transfer function of uniform motion blur contains zero-crossings where frequency values are zero. At these specific frequencies, direct inverse filtering is mathematically undefined, preventing perfect reconstruction of those particular components.

230. (D) Calculate target coordinate $\backslash to$ Apply inverse spatial transform matrix $\backslash to$ Determine source coordinate $\backslash to$ Interpolate gray level
Inverse mapping is a robust method for geometric transformation. It begins by selecting a discrete target pixel coordinate. The inverse spatial transformation matrix is then applied to map this target location back to its corresponding source coordinate. Finally, because this source position is often fractional, interpolation determines the appropriate intensity value.

231. (B) CMYK
The CMYK color model relies on the subtractive properties of ink on paper to render colors. Cyan, magenta, and yellow pigments act as filters that subtract specific wavelengths from white light, while key, representing black, is added to improve density. This model forms the foundation for professional color printing technologies.

232. (C) Vector processing maintains cross-channel correlation.
Processing color channels independently can lead to color artifacts because it ignores the statistical dependencies between the red, green, and blue components. In contrast, treating pixels as color vectors in a multi-dimensional space preserves cross-channel correlations, ensuring that transformations like smoothing or sharpening maintain color consistency and edge integrity.

233. (D) Erosion
In mathematical morphology, erosion is the fundamental operation that shrinks foreground objects. This operation is defined as the Minkowski set subtraction of a structuring element from the input image. It identifies all spatial locations where the structuring element fits entirely inside the object, thereby removing pixels along its boundaries.

234. (A) Connected Components Extraction
Connected components extraction is an iterative morphological algorithm used to identify and isolate separate objects in a binary image. Starting from a seed point within an object, the algorithm recursively dilates the seed and intersects it with the original image until no more pixels are added, successfully extracting the entire connected component.

235. (B) Infinite values of slope m for vertical lines
The slope-intercept parameterization of lines fails when representing vertical lines, because their slope is infinite. This infinity prevents the construction of a bounded accumulator array. Utilizing the polar coordinate system resolves this mathematical limitation by representing all possible lines within a finite parameter space, where coordinates remain strictly bounded.

NODIA

236. (B) Watershed lines
To segment adjacent regions, the watershed algorithm simulates the flooding of a topographic surface. As water rises from local minima, different catchment basins begin to merge. To prevent this, the algorithm constructs dams at the points of contact. These dams form the watershed lines, which represent the final segmentation boundaries.

177. (B) It avoids multiplications by using only additions and subtractions.
The Hadamard transform is defined by a symmetric matrix containing only positive and negative ones. Because its basis vectors are binary, computing the forward and inverse transforms requires only arithmetic addition and subtraction operations. This unique characteristic completely eliminates the need for complex floating-point multiplications, offering highly efficient computational speed.

178. (D) Its basis vectors depend on the image's covariance matrix.
Unlike the Fourier or Cosine transforms, which use fixed, data-independent sinusoidal basis functions, the Karhunen-Loève Transform is entirely data-dependent. Its basis vectors must be calculated explicitly from the covariance matrix of the input image. This dynamic requirement prevents the development of a universal, fast pre-structured algorithm for computing the KLT.

179. (A) $\gamma_H > 1$ and $\gamma_L < 1$
Homomorphic filtering improves image appearance by compressing dynamic range and increasing contrast. In this model, illumination represents low frequencies and reflectance represents high frequencies. To achieve this, the high-frequency gain must be set greater than one to enhance detail contrast, while the low-frequency gain must be less than one to reduce illumination variation.

180. (C) Zero-padding $\backslash to$ Fourier Transform $\backslash to$ Filter Multiplication $\backslash to$ Inverse Fourier Transform $\backslash to$ Crop
To perform frequency domain filtering without introducing wrap-around spatial aliasing, the input image must first be zero-padded. After padding, the image is converted using the Fourier transform, and then multiplied by the frequency filter. The inverse transform is applied to return to the spatial domain, which is cropped to recover the original size.

181. (A) It enforces a smoothness constraint to reduce artifacts.
The Constrained Least Squares filter is often visually superior to the Wiener filter because it explicitly incorporates a smoothness constraint into the optimization problem. This constraint, typically based on a Laplacian operator, minimizes high-frequency noise and oscillations, thereby reducing ringing artifacts and delivering smoother, more natural-looking restored images.

182. (D) Bicubic
Bicubic interpolation is an advanced spatial reconstruction technique that calculates the intensity of a transformed pixel using a weighted average of sixteen neighboring pixels. By fitting a mathematically complex cubic polynomial over this four-by-four grid, it preserves fine structural details and produces much smoother transitions than simpler nearest-neighbor or bilinear methods.

183. (B) White
Under the additive color mixing model, different wavelengths of light combine to create new colors. The primary colors of this system are red, green, and blue. When these three primary colors are projected and superimposed at equal and maximum intensity, they stimulate all human photoreceptors, producing the visual perception of white light.

184. (C) The relative RGB ratios are changed, distorting the hue.
Applying histogram equalization independently to the red, green, and blue color channels of an image modifies their intensity distributions separately. This independent adjustment alters the relative ratios between the channels at each pixel location. As a result, the perceived hue is severely distorted, introducing artificial and unrealistic color shifts.

185. (D) Watershed on the distance transform
When binary circular objects overlap, simple thresholding cannot separate them. Applying the distance transform converts the binary shapes into a topographic surface where the center of each circle becomes a local minimum. Running the watershed algorithm on this inverted distance map identifies the narrow boundaries between the objects, successfully separating them.

186. (A) Opening
The morphological opening operation is defined as erosion followed by dilation using the same structuring element. This operation acts as a geometric filter that smooths object contours, eliminates thin protrusions, and breaks narrow isthmuses connecting distinct regions. It removes foreground features that are smaller than the

Click Here to Buy book on Amazon

248. (C) Complex exponentials
The mathematical formulation of the two-dimensional Discrete Fourier Transform decomposes an image into a linear combination of complex exponentials. These complex exponentials represent sinusoidal waves of varying spatial frequencies, phases, and orientations, mapping the spatial domain information directly into the frequency spectrum for advanced analysis and filtering.

249. (D) Orthogonality
The Discrete Cosine Transform matrix is mathematically designed to be orthogonal. This property means that the rows and columns of the transform matrix form an orthonormal set. Consequently, the inverse transform matrix is simply equal to its transpose, which eliminates the need to calculate complex matrix inversions during decompression.

250. (A) Karhunen-Loève Transform (KLT)
The Karhunen-Loève Transform is an optimal linear transformation that rotates the coordinate system of an image dataset. By calculating the eigenvectors of the covariance matrix, it aligns the new coordinate axes along the directions of maximum statistical variance, ensuring that the first principal component captures the greatest amount of variation.

251. (B) It compresses illumination range and enhances reflectance contrast.
By applying a logarithmic transformation, homomorphic filtering separates an image into low-frequency illumination and high-frequency reflectance components. Filtering then compresses the dynamic range of the illumination, reducing shadows and highlights, while simultaneously amplifying the reflectance components. This joint action dramatically enhances local contrast and details across the entire image.

252. (B) Gaussian PDF
Gaussian noise is a standard noise model in digital imaging, characterized by a probability density function that exhibits a symmetric, bell-shaped curve. This distribution indicates that noise values close to the mean are highly likely, while extreme variations are rare. It effectively models random electronic noise generated during image acquisition.

253. (A) Adaptive local noise filter
The adaptive local noise filter dynamically adjusts its behavior based on local neighborhood statistics. In smooth regions with low variance, it behaves like a standard mean filter to suppress noise. Near sharp edges where the local variance is high, the filter reduces its smoothing action to preserve edge sharpness and detail.

254. (C) Bicubic interpolation
Bicubic interpolation is an advanced spatial reconstruction method that evaluates a sixteen-pixel neighborhood to determine transformed values. Although it requires significantly more computational power than nearest-neighbor or bilinear methods, it produces highly smooth results and minimizes blocky artifacts, making it ideal for high-quality geometric scaling of digital images.

NODIA

255. (D) Hue
In the HSI color model, hue represents the dominant wavelength of a color. It is mathematically defined as an angle ranging from zero to three hundred sixty degrees around the vertical intensity axis, with red positioned at zero degrees. Hue describes the pure color sensation, independent of its saturation or brightness.

256. (C) Convert to HSI, adjust Intensity, and convert back.
To adjust the overall brightness of a color image without distorting its color characteristics, the image is converted to the HSI color model. The intensity channel is then modified independently, while keeping hue and saturation constant. Finally, converting back to RGB yields the brightened image with its original color tones preserved.

257. (B) Top-hat transform
The morphological top-hat transform is computed by subtracting the opened version of an image from the original image. Because opening removes bright objects that are smaller than the structuring element, this subtraction isolates those small, bright features. This operation is highly effective for correcting uneven background illumination and highlighting small details.

258. (D) The homogeneity criteria required to append a pixel.
In region growing, a logical predicate defines the homogeneity criteria used to determine

CHAPTER 09

Microcontroller, PLC, SCADA Programming and Their Applications

2014

1. Which boolean operation is exclusively utilized to determine if two logic signals are in different states?
(A) NAND
(B) XOR
(C) NOR
(D) AND

2008

2. What distinguishes Harvard architecture from Von Neumann architecture in microcontrollers?
(A) Unified memory space for both instructions and data
(B) Absence of an internal Arithmetic Logic Unit component
(C) Single shared data bus serving all on-chip peripherals
(D) Separate memory buses for instructions and data

2003

3. Which internal component of a standard microcontroller is responsible for generating the clock signals required for synchronization?
(A) Oscillator circuit
(B) Watchdog Timer
(C) Analog-to-Digital Converter
(D) General Purpose Register

2001

4. Which of the following statements about microcontroller addressing modes is correct?
(A) Direct addressing stores the operand value directly within the instruction opcode.
(B) Immediate addressing fetches configuration data from an external non-volatile memory.
(C) Indirect addressing uses a register to hold the memory location of the data.
(D) Indexed addressing is a specialized mode only applicable to high-end microprocessors.

2021

5. Identify the INCORRECT statement regarding microcontroller peripherals.
(A) Hardware interrupts must be triggered by internal software events exclusively.
(B) Timers can be configured to operate as event counters using external pulses.
(C) I/O ports can generally be configured as either inputs or outputs.
(D) Interrupt Service Routines (ISRs) execute when a specific trigger condition is met.

2002

6. In a Programmable Logic Controller (PLC), what constitutes the scan cycle mechanism?
(A) Writing inputs, executing logic, reading outputs
(B) Executing logic, writing inputs, reading outputs
(C) Reading outputs, writing inputs, executing logic
(D) Reading inputs, executing logic, writing outputs

2004

7. What is the primary reason for selecting a sinking input module in a PLC system?
(A) The field device acts as a sinking type, requiring the module to supply current.
(B) The field device acts as a sourcing type, supplying positive voltage to the module.
(C) The system requires continuous high-frequency analog signals.
(D) The module is dedicated to driving high-power AC output loads.

2001

8. How are PLC power supplies designed to protect internal digital circuits from AC mains fluctuations?
(A) By providing physical weight and structural reinforcement
(B) By using localized high-frequency acoustic mufflers
(C) By employing galvanic isolation and noise filtering
(D) By maximizing the number of physical

Downloaded from www.pdf.tube

NODIA

269. (A) Ridgelines of the gradient image
The morphological watershed segmentation algorithm treats a grayscale image as a topographic surface. To extract boundaries between distinct regions, the algorithm identifies the ridgelines that separate different catchment basins. These ridgelines represent the locations of local maximum intensity changes, corresponding to the sharp edges of the gradient image.

270. (C) Prevent error accumulation by matching encoder and decoder values.
In lossy predictive coding, the encoder includes a replica of the decoder's quantizer loop. This loop ensures that both the encoder and decoder base their predictions on the exact same reconstructed, quantized pixel values. This matching prevents the accumulation of quantization errors across successive pixels, stabilizing the reconstruction quality.

****

(A) Devices are connected in a continuous closed loop.
(B) Devices share a single common communication trunk line.
(C) Devices communicate exclusively via wireless radio frequency.
(D) All devices connect directly to a central hub or switch.

2003

19. The 4-20 mA industrial signal standard is widely adopted because it provides which intrinsic feature?
(A) Inherent detection of a broken wire
(B) Provision of mathematically infinite signal resolution
(C) Bidirectional digital communication capabilities by default
(D) Absolute physical immunity to all electromagnetic interference

2017

20. Which statement correctly describes the multidrop mode in HART communication?
(A) Analog signals remain fully and continuously proportional to the primary process variable.
(B) Only one downstream slave field device can be physically connected to the host master.
(C) The analog current is fixed at 4 mA using only digital data.
(D) All connected field devices operate seamlessly without requiring unique polling addresses.

2012

21. Which statement about Fieldbus architecture is INCORRECT?
(A) It exclusively utilizes unshielded twisted pair wiring.
(B) It supports multidrop networking configurations of smart instruments.
(C) It typically replaces legacy centralized point-to-point wiring layouts.
(D) It provides extensive device-level diagnostic data alongside process values.

2021

22. What arbitration mechanism does the CAN bus standard use to handle simultaneous transmissions?
(A) Token passing protocol
(B) Centralized master-slave polling
(C) Time Division Multiple Access (TDMA)
(D) CSMA with Collision Resolution (CSMA/CR)

2004

23. Which basic building block of a computer-based Data Acquisition (DAQ) system converts continuous physical signals into digital numbers?
(A) Signal conditioner
(B) Analog-to-Digital Converter
(C) Multiplexer
(D) Digital-to-Analog Converter

2002

24. Compared to a local PLC, what is the defining characteristic of a SCADA system?
(A) It controls a single high-speed discrete machine process.
(B) It is incapable of integrating Human Machine Interface components.
(C) It performs supervisory control over geographically distributed assets.
(D) It operates completely independently of Master Terminal Unit hardware.

2005

25. Match the SCADA components in List I with their primary functions in List II:
List I: (SCADA Components)
P. MTU
Q. RTU
R. HMI
S. Communication Network
List II: (Primary Functions)
1. Interfaces directly with field sensors and actuators
2. Displays graphical process data to human operators
3. Acts as the central supervisory controller
4. Provides the transmission medium for data exchange
(A) P-3, Q-1, R-2, S-4
(B) P-1, Q-3, R-4, S-2
(C) P-3, Q-2, R-1, S-4
(D) P-2, Q-4, R-3, S-1

2023

26. Which of the following logic gates is a universal gate?
(A) AND
(B) OR
(C) NAND
(D) XOR

2018

27. What is the most appropriate reason to select a microcontroller over a microprocessor for a simple embedded application?
(A) Significantly higher maximum internal processor clock speed

Click Here to Buy book on Flipkart

output terminals

2013

9. In comparison to traditional hardwired relay logic, what is a distinct characteristic of PLC ladder logic diagrams?
(A) Ladder logic requires physical rewiring of circuits to change control sequences.
(B) Ladder logic executes all program rungs simultaneously rather than sequentially.
(C) Ladder logic completely eliminates the requirement for any external power supplies.
(D) Ladder logic allows logical contacts to be reused infinitely in the software.

2022

10. How is a Retentive Timer (RTO) fundamentally different from a Timer On Delay (TON) in PLC programming?
(A) RTO maintains its accumulated value when the rung condition goes false.
(B) TON maintains its accumulated value when the rung condition goes false.
(C) RTO resets automatically after reaching the preset value.
(D) TON requires a dedicated and separate reset instruction to clear its accumulator.

2008

11. What can be inferred about a PLC system that utilizes a word-based memory mapping format?
(A) It is incapable of processing standard boolean discrete inputs.
(B) It maps individual bits within larger memory registers.
(C) It demands the installation of external floating-point processors.
(D) It exclusively supports analog sensor signal inputs.

2005

12. If a PLC programmer needs to determine if a sensor value is strictly below a threshold, which instruction is most appropriate?
(A) EQU
(B) LES
(C) NEQ
(D) GRT

2007

13. What is the primary advantage of using a Master Control Relay (MCR) instruction in a PLC program?
(A) It de-energizes a specific zone of outputs simultaneously.
(B) It increases the CPU processor's average scan time.
(C) It completely replaces the physical hardwired emergency stop button.
(D) It automatically calibrates incoming analog signals.

2016

14. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): A bitwise AND operation can be used to mask specific bits in a PLC data register.
Reason (R): The bitwise AND output is 1 only when the corresponding bits of both operands are 1.
(A) Both A and R are true but R is not the correct explanation of A.
(B) Both A and R are true and R is the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2019

15. Which of the following is NOT a standard sequencer instruction in PLC programming?
(A) SQO
(B) SQC
(C) SQL
(D) SQX

2024

16. What is the best method to resolve scaling issues in an analog PLC module where a 4-20mA signal must represent 0-100 degrees Celsius?
(A) Manually adjust the calibration screw on the physical sensor output transmitter directly.
(B) Reconfigure and modify the programmable logic controller's internal default scan time.
(C) Apply a linear scaling instruction using the slope-intercept formula.
(D) Completely ignore the standard four milliampere offset value and multiply the raw reading by five.

2025

17. In a PID control loop for a continuous process, what does the Integral (I) term primarily eliminate?
(A) High-frequency noise
(B) Steady-state error
(C) Overshoot during startup
(D) Deadband hysteresis

2003

18. What defines a star topology in industrial PLC networking?

Downloaded from www.pdf.tube

(A) Multiply two source values and store the result.
(B) Multiply the current discrete input state by the exact scan cycle duration value.
(C) Multiply the total accumulated timer value by a pre-defined constant scale offset.
(D) Multiplex multiple high-frequency analog inputs into a single shared data channel.

2022
38. How is a Subroutine (SBR) function related to overall PLC program execution time?
(A) It permanently halts the main system program scan.
(B) It delays the processor's scan cycle to match slower analog updates.
(C) It requires a dedicated physical hardware co-processor to execute.
(D) It reduces execution time by running code only when called.

2024
39. Identify the correct pair of data manipulation instruction and its function:
(A) MOV - Converts high-level hexadecimal formats directly into binary
(B) BSL - Shifts bit arrays to the left
(C) AND - Shifts individual bits to the far left position of a word
(D) OR - Moves a designated data word to another address without modification

2024
40. Identify the INCORRECT pair regarding PLC sequencers:
(A) SQO - Sequencer Output
(B) SQC - Sequencer Compare
(C) SQI - Sequencer Integral
(D) SQL - Sequencer Load function

2016
41. Which of the following is NOT a characteristic of a PLC Analog-to-Digital (A/D) converter?
(A) Inherent physical sampling rate limitations
(B) Measurement resolution defined strictly by bit depth
(C) High-accuracy voltage reference dependency
(D) Quantization-free infinite precision

2005
42. Consider the following statements regarding PID loop tuning in a PLC:
I. Increasing the proportional gain always stabilizes the system.
II. The derivative term anticipates future error based on its rate of change.
III. The integral term addresses steady-state offset.
IV. Loop tuning involves adjusting P, I, and D parameters for optimal response.
Which of the above statements are correct?
(A) I, II and IV
(B) I and III
(C) II, III and IV
(D) I, II and III

2019
43. Compared to an Ethernet/IP network, what is a typical limitation of a classic RS-485 based Modbus RTU network in PLCs?
(A) It strictly requires high-speed industrial fiber optic cables.
(B) It operates at lower transmission speeds.
(C) It is physically incapable of supporting more than two total devices.
(D) It is completely incapable of transmitting continuous analog data words.

2002
44. What happens in a standard 4-20 mA loop if the signal current drops to 0 mA?
(A) The PLC immediately registers its absolute maximum full-scale value.
(B) The controller detects a wire fault.
(C) The host system automatically interprets it as a negative process variable.
(D) The internal PID controller rapidly increases its derivative calculation action.

2013
45. Which of the following is a "Universal Command" in the HART protocol?
(A) Read primary variable
(B) Calibrate sensor zero
(C) Adjust damping time
(D) Write unique manufacturer data

2005
46. What defines the basic architecture of a Fieldbus system?
(A) A legacy and purely analog infrastructure utilizing standard zero to ten volt signals.
(B) A highly localized hydraulic control network utilizing high-pressure fluid valves.
(C) A digital, multi-drop link among intelligent devices.
(D) A restrictive star-only topology requiring dedicated physical wires for every field device.

NODIA

(B) On-chip integration of memory and peripherals
(C) Frequent and mandatory need for external memory expansion chips
(D) Inherent ability to run highly complex desktop operating systems

2009

28. Based on standard memory organization, what can be inferred if a microcontroller specifies a separate register file for the Arithmetic Logic Unit (ALU)?
(A) It completely lacks any internal random-access memory (RAM) storage space.
(B) It employs a load-store architecture.
(C) It utilizes direct memory access hardware controllers for all internal operations.
(D) It must rely exclusively and continuously on external high-speed flash memory.

2019

29. What is the direct effect of executing a 'Return from Interrupt' (RETI) instruction in a microcontroller?
(A) The processor restores the Program Counter and re-enables interrupts.
(B) The CPU clears all data from internal RAM registers.
(C) The microcontroller immediately enters a low-power sleep state.
(D) The instruction forces an automatic reset of the watchdog timer.

2021

30. By eliminating the necessity for software polling, which microcontroller peripheral drastically reduces CPU overhead for detecting external events?
(A) Watchdog Safety Timer
(B) Asynchronous UART Serial Port
(C) External Interrupts
(D) Pulse Width Modulator Unit

2014

31. Consider the following statements regarding the PLC scan cycle:
I. The scan cycle always executes outputs before reading inputs.
II. A longer scan time can result in missed transient input signals.
III. The CPU memory updates asynchronously regardless of the scan phase.
Which of the above statements are INCORRECT?
(A) I and II
(B) I and III
(C) II and III
(D) I only

2022

32. A discrete PLC input module typically processes which type of signals?
(A) 4-20 mA current loops
(B) 0-10V DC variable voltage
(C) ON/OFF binary states
(D) Thermocouple millivolts

2009

33. What is the primary function of an optical isolator in a PLC input circuit?
(A) To electrically amplify the weak incoming analog signal voltage before processing
(B) To isolate low-voltage logic from high-voltage field wiring
(C) To dynamically convert continuous analog signals into standardized digital values
(D) To provide real-time visual indication of current input status via diagnostic LEDs

2008

34. In relay logic terminology, what does the abbreviation "NO" stand for?
(A) Negative Output
(B) Neutral Operation
(C) Node Offset
(D) Normally Open

2014

35. What is the primary disadvantage of using multiple cascading timers instead of a dedicated counter in a PLC program?
(A) It increases complexity and wastes memory.
(B) Dedicated timer instructions always consume less memory space than counters.
(C) Cascading multiple timers provides significantly higher precision for event counting.
(D) Timer instructions cannot be cleared or reset by any external physical inputs.

2019

36. Which data type typically occupies 16 bits in modern PLC memory organization?
(A) Boolean
(B) Double Integer (DINT)
(C) Integer (INT)
(D) Real / Float

2007

37. The fundamental concept of the MUL instruction in PLC arithmetic requires the processor to do what?

Click Here to Buy book on Amazon

(A) Baud rate
(B) Propagation delay
(C) Scan time
(D) Settling time

2023
57. The concept of "sourcing" in a PLC DC output module implies what?
(A) The output module actively switches the common ground return path for the load.
(B) The output module dynamically provides a continuous high-frequency alternating current.
(C) The output module physically acts as a static infinite resistor within the circuit.
(D) The module supplies voltage to the load.

2001
58. What is the primary function of electrical noise mitigation in a PLC power supply?
(A) Preventing electromagnetic interference (EMI) from disrupting processing logic
(B) Intentionally increasing the mechanical hum of the transformer core
(C) Converting high-speed digital signals to variable analog voltages
(D) Constantly shifting the line frequency of the primary AC power mains

2010
59. What defines a "coil" in fundamental PLC ladder logic?
(A) A physical mechanical spring situated inside the processor chip
(B) An output that energizes when rung conditions are met
(C) An external input condition that must be met to pass power
(D) A digital network packet routed through serial ports

2003
60. Identify the INCORRECT statement concerning PLC counters.
(A) CTU increments its value on a false-to-true transition.
(B) CTD increments its value on a true-to-false transition.
(C) Counters generally require a separate reset instruction.
(D) A counter retains its accumulated value on power loss if retentive.

NODIA

2003
61. Comparing octal and decimal memory addressing in older versus modern PLCs, what is a key difference?
(A) Octal omits digits 8 and 9, unlike standard decimal systems.
(B) Decimal addressing formats strictly limit total program memory.
(C) Octal memory addressing is faster for the ALU to process.
(D) Modern PLCs completely prohibit tag-based addressing schemes.

2023
62. What is an advantage of using a dedicated DIV instruction instead of a loop of subtractions in a PLC?
(A) It reduces the memory storage capacity of the CPU.
(B) It automatically converts single integers to double-precision floats.
(C) It minimizes CPU scan time and program overhead.
(D) It physically scales the output voltage on the terminal blocks.

2016
63. What is the effect of executing a Jump (JMP) instruction to a forward Label (LBL) in a PLC program?
(A) The PLC processor immediately enters a critical system fault state.
(B) All outputs in the skipped rungs are immediately energized.
(C) The direction of the program scan is completely reversed.
(D) Rungs between the JMP and LBL instructions are skipped.

2004
64. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): A shift register instruction can be used to track parts moving along a conveyor belt.
Reason (R): Shift registers move a bit array sequentially upon each false-to-true transition of the input condition.
(A) Both A and R are true but R is not the correct explanation of A.
(B) A is true but R is false.
(C) A is false but R is true.
(D) Both A and R are true and R is the correct explanation of A.

2017

47. What causes a dominant bit to overwrite a recessive bit on a CAN bus?
(A) The centralized master controller transmitting an overriding network token.
(B) The automated high-priority error frame generation sequence on the bus.
(C) The complete lack of standard termination resistors at network endpoints.
(D) Wired-AND logic at the physical layer.

2016

48. In a data acquisition system, what inference can be made if the sampling frequency is lower than the Nyquist rate?
(A) The digital signal will be perfectly reconstructed.
(B) The analog-to-digital converter will overheat.
(C) Aliasing will occur, distorting the recorded signal.
(D) The overall signal-to-noise ratio will improve significantly under this condition.

2006

49. Which feature makes SCADA Human Machine Interfaces (HMIs) most appropriate for industrial supervision?
(A) The dedicated ability to directly compile complex PLC ladder logic programs locally.
(B) Real-time visualization and alarm management.
(C) Absolute and complete independence from all standard communication protocols.
(D) Direct execution of high-voltage physical electrical power switching operations.

2021

50. By eliminating standard PLC systems, an architecture relying purely on RTUs communicating directly with an MTU is most likely characterizing what?
(A) A closed-loop continuous PID controller unit
(B) A single-machine automated manufacturing cell
(C) A standalone multi-variable HART transmitter device
(D) A distributed SCADA system

2012

51. The relationship between Boolean algebra and PLC ladder logic is best described by which statement?
(A) Ladder rungs represent Boolean equations.
(B) Industrial ladder logic is fundamentally and completely incompatible with Boolean algebra.
(C) Theoretical Boolean logic strictly requires hardware relays, whereas modern ladder logic does not.
(D) Mathematical Boolean algebra exclusively and only applies to continuous analog PID feedback loops.

2001

52. Which classification accurately describes a microcontroller combining CPU, memory, and I/O on a single chip?
(A) General-purpose computer
(B) Supercomputer
(C) System on a Chip (SoC) / Embedded system
(D) Application-Specific Integrated Circuit (ASIC)

2009

53. Consider the following statements regarding microcontroller architecture:
I. The ALU performs bitwise logic operations.
II. Flash memory is typically used to store the executable code.
III. SRAM loses its data when power is removed.
IV. Watchdog timers reset the system if the software hangs.
V. All microcontrollers lack internal clock generation.
Which of the above statements are correct?
(A) I, II, III and IV
(B) I, III, IV and V
(C) II, III, IV and V
(D) I, II and V

2016

54. Which addressing mode is NOT generally found in basic 8-bit microcontrollers?
(A) Immediate
(B) Direct
(C) Indexed
(D) 64-bit virtual addressing

2023

55. Identify the correct statement regarding microcontroller timers.
(A) They function as purely high-frequency analog devices.
(B) They can generate PWM signals.
(C) They operate entirely independently of the internal system clock.
(D) They are impossible to configure or program using C language.

2007

56. What specifies the time it takes for a PLC to evaluate all logic rungs once?

Downloaded from www.pdf.tube

whether a neighboring pixel should be added to the active region. This predicate typically evaluates features like gray-level intensity, color, or texture similarity, ensuring that the grown region remains homogeneous and consistent in its physical characteristics.

259. (A) Local edge linking
Local edge linking is a spatial processing technique used to connect individual edge points into a continuous boundary. The algorithm evaluates a local neighborhood and links adjacent pixels if they possess similar gradient magnitudes and direction angles, effectively grouping them into meaningful structural segments based on local proximity.

260. (C) Co-occurrence matrix
The co-occurrence matrix is a statistical method used to describe regional texture. It measures the spatial distribution of gray levels by calculating how frequently pairs of pixels with specific intensity values occur at a predefined distance and orientation, providing a robust representation of texture properties like contrast and homogeneity.

261. (A) Psychovisual redundancy
Psychovisual redundancy refers to information that is registered by the human eye but is not critical for visual perception. Because the human visual system is insensitive to certain high-frequency spatial details and color variations, these components can be discarded during lossy compression without any visible degradation, achieving significant compression gains.

262. (D) GIF
The Graphics Interchange Format, commonly known as GIF, is a popular image file format that intrinsically utilizes Lempel-Ziv-Welch lossless compression. This algorithm reduces file size by identifying and encoding repetitive patterns in the image data, ensuring that the decompressed image is mathematically identical to the original uncompressed source.

263. (B) 7
The City-block distance, also known as the D_4 metric, is calculated as the sum of the absolute differences between coordinates. For the path between the origin at coordinate zero, zero and the point three, four, the distance is the absolute value of three plus the absolute value of four, which equals seven.

264. (C) Noise dominates at high frequencies where degradation approaches zero.
Perfect image restoration via inverse filtering is practically impossible because real-world images contain additive noise. At high frequencies, the blur degradation function often drops to near-zero values. Dividing by these tiny values enormously amplifies the high-frequency noise, completely overwhelming the reconstructed signal and rendering the restored image unusable.

265. (D) Convolution Theorem
The convolution theorem is a fundamental concept in Fourier analysis. It states that spatial convolution between an image and a filter kernel is mathematically equivalent to point-by-point multiplication of their respective frequency spectra. This relationship allows complex spatial filtering operations to be computed highly efficiently in the frequency domain.

266. (A) Abrupt transitions and constant-intensity regions
The 2D Haar transform decomposes an image using step-like basis functions, which are characterized by constant positive and negative values. This unique design makes the Haar transform exceptionally efficient for analyzing images containing abrupt intensity transitions, such as sharp edges, alongside large, homogeneous regions of constant gray levels.

NODIA

267. (B) Bilinear spatial mapping
Bilinear spatial mapping is a geometric transformation technique used to correct non-linear distortions. It requires identifying four distinct control points, or tie-points, in both the input and output images. These four coordinate pairs provide the necessary system of equations to solve for the eight coefficients of the bilinear mapping equations.

268. (B) Hu's Invariant Moments
Hu's invariant moments are a set of seven mathematical descriptors derived from normalized central moments of an image. These seven values are highly useful for shape analysis because they remain strictly constant under spatial translation, scale changes, and rotation, providing a highly robust representation of an object's boundary geometry.

2003

65. If a PLC SQL (Sequencer Load) instruction is triggered, what can be inferred about the data?
(A) The sequencer data array is permanently erased.
(B) Data is written into the sequencer array at the current step.
(C) The connected physical outputs are unconditionally forced on.
(D) The logic solver scan cycle duration is automatically halved.

2017

66. Which metric is most appropriate for determining the smallest change in voltage a PLC analog input can detect?
(A) Amplifier gain
(B) Baud rate
(C) Average network transmission latency
(D) Resolution (e.g., 12-bit, 16-bit)

2007

67. Under which classification does PID control fall within industrial automation?
(A) Continuous closed-loop control
(B) Discrete sequential control
(C) Open-loop relay logic
(D) Time-based combinational logic

2007

68. Identify the correct pair of industrial communication interface and its typical physical layer:
(A) Modbus RTU - Fiber Optics
(B) Ethernet/IP - RS-232
(C) PROFIBUS DP - RS-485
(D) DeviceNet - CAT6 twisted pair

2017

69. By eliminating 0-20 mA systems, why did the industry standard settle on 4-20 mA?
(A) The 4 mA offset detects broken wires.
(B) A constant 4 mA current provides significantly more operating power directly to the host PLC CPU.
(C) A reading of exactly 0 mA mathematically represents a true zero value of the physical process variable.
(D) An upper limit of 20 mA is inherently safer for human operators handling bare wire terminals.

2005

70. Which is a negative aspect (disadvantage) of using point-to-point HART communication compared to multidrop?
(A) It prevents standard analog loop signaling entirely.
(B) It forces all connected devices to use a uniform 4 mA current.
(C) It limits the digital communication rate to exactly 1200 bps.
(D) It requires dedicated point-to-point wiring for each device.

2019

71. The concept of "interoperability" in Fieldbus architectures implies:
(A) All field devices can physically and seamlessly interchange their primary electrical power supplies.
(B) Different brands of devices work on the same bus.
(C) Analog and digital communication signals must always travel on separate highly shielded physical cables.
(D) The industrial communication network requires absolutely no software configuration or driver setup.

2007

72. Which identifier format is used by the Extended CAN frame standard (CAN 2.0B)?
(A) 8-bit ID
(B) 11-bit ID
(C) 29-bit ID
(D) 64-bit wide ID

2025

73. What fundamental principle relies on sampling physical properties like temperature or pressure and converting them into digital data?
(A) Pulse Width Modulation
(B) Boolean Logic
(C) Arbitrary Waveform Generation
(D) Data Acquisition (DAQ)

2016

74. What defines a Remote Terminal Unit (RTU) in the context of SCADA?
(A) A field device interfacing sensors via telemetry.
(B) A centralized server computer hosting and running the graphical supervisory control HMI software.
(C) A dedicated, hand-held manual programmer unit utilized to configure on-board microcontrollers.
(D) A standard high-performance desktop computer optimized for relational database management systems.

Click Here to Buy book on Flipkart

II. PLC memory is strictly limited to 1 Megabyte in all models.
III. The scan cycle mechanism is unique to SCADA MTUs, not PLCs.

Which of the above statements are INCORRECT?
(A) I and II
(B) I and III
(C) I, II and III
(D) II and III

2018

132. What type of isolation is most commonly used in discrete PLC I/O modules?
(A) Magnetic isolation
(B) Acoustic isolation
(C) Optical isolation
(D) Thermal isolation

2002

133. Compared to linear power supplies, what is a primary characteristic of switch-mode power supplies (SMPS) used in PLCs?
(A) Higher efficiency and smaller size, but with more electrical noise.
(B) Lower efficiency and larger physical footprint with less noise.
(C) Complete inability to regulate voltage under changing loads.
(D) Outputting high-voltage AC waveforms instead of stable DC.

2018

134. If a PLC rung has three normally open contacts in series, what inference can be made about the output coil?
(A) It functions logically as a standard OR gate.
(B) The output coil will energize if any single contact closes.
(C) The output coil remains permanently latched once energized.
(D) It energizes only when all three contacts are closed.

2004

135. The relationship between a Timer On Delay (TON) preset value and its accumulated value is:
(A) The accumulated value must always exceed the preset value to begin timing.
(B) When the accumulated value equals the preset value, the done bit is set.
(C) The preset value increments continuously while the accumulated value remains static.
(D) When the preset value is reached, the timer immediately begins counting down to zero.

2007

136. Which statement accurately describes bit-level memory addressing in PLCs?
(A) It treats all memory locations as double-word structures for floating-point values.
(B) It groups sixteen bits together to process them as a single integer.
(C) It allows the addressing and manipulation of individual binary states.
(D) It requires dedicated external network interfaces to map individual data points.

2008

137. What causes an overflow error flag to set during a PLC ADD instruction?
(A) The memory registers for the two input operands are uninitialized.
(B) The logic executes multiple mathematical instructions in a single scan.
(C) The input parameters are configured with mismatched data formats.
(D) The sum exceeds the maximum limit of the destination data type.

2018

138. Under which classification does the PLC Skip (SKP) instruction fall?
(A) Program Flow Control
(B) Data Manipulation
(C) Sequencer Operations
(D) Arithmetic Operations

NODIA

2003

139. By eliminating the lower 4 bits of an 8-bit register, which data manipulation operation is typically being applied?
(A) Logical OR with 0x0F
(B) Logical AND with 0xF0
(C) Logical XOR with 0xFF
(D) Bitwise logical NOT

2021

140. What is the definition of a matrix operation in advanced PLC programming?
(A) Converting continuous analog signals to equivalent digital registers.
(B) Manipulating or comparing multi-word data arrays concurrently.
(C) Performing fast Fourier transforms on high-speed frequency inputs.
(D) Mapping physical remote input terminals directly to logic tags.

2019

141. A/D converters operate by:
(A) Sampling analog inputs to assign binary

proper grounding
(B) Running signal wires parallel to high-voltage power lines
(C) Using unshielded cables
(D) Increasing the scan time artificially

2022
84. Under which programming language classification does Ladder Logic fall according to IEC 61131-3?
(A) Object-Oriented Structure Language
(B) Textual-Based Programming Language
(C) Graphical Language
(D) Low-Level Machine Assembly Language

2014
85. What is the main advantage of using a Counter Down (CTD) instruction in a batching process?
(A) It reaches zero when depleted, simplifying stop logic.
(B) It automatically refills the processing hopper without extra code.
(C) It dynamically generates a variable analog voltage output.
(D) It resets the PLC scan cycle to zero.

2007
86. Consider the following steps in a standard PLC scan cycle:
I. Execute user program logic
II. Read physical inputs and update input image table
III. Perform internal diagnostics and communications
IV. Update physical outputs from output image table
Which of the following represents the correct sequential order of these steps?
(A) I, II, III, IV
(B) II, I, IV, III
(C) III, II, IV, I
(D) IV, III, II, I

2023
87. What can be inferred if a PLC program attempts to DIV by a register containing the value zero?
(A) The result is calculated as positive infinity by the ALU.
(B) A division-by-zero math fault occurs, potentially halting execution.
(C) The PLC ignores the instruction and continues execution normally.
(D) The divisor value is automatically changed to positive one.

2002
88. Identify the correct statement regarding PLC Subroutine functions:
(A) Subroutines always execute uninterrupted regardless of jump commands.
(B) Subroutines cannot process, pass, or return dynamic parameters.
(C) Subroutines modularize code and reduce memory usage.
(D) A standard return instruction is not required at the end of a subroutine.

2010
89. The concept of a bitwise shift register in PLCs is primarily applied to:
(A) Regulating temperature profiles in a continuous thermal process.
(B) Establishing serial communication with a SCADA database.
(C) Converting incoming AC power to stable DC operating voltage.
(D) Tracking products moving along automated conveyors.

NODIA

2018
90. Which instruction compares the input data against reference data in a sequencer operation?
(A) SQC
(B) SQO
(C) SQL
(D) SQR

2008
91. What is the definition of "resolution" in an analog PLC module?
(A) The absolute maximum voltage potential the input module can physically handle without damage.
(B) The smallest change the ADC can convert and represent.
(C) The maximum processing speed capability of the built-on internal digital optical isolator.
(D) The maximum theoretical distance the analog signal can travel through standard loop wiring.

2014
92. Consider the following statements regarding PID loop concepts:
I. Proportional control depends only on the current error.
II. Derivative control is highly sensitive to measurement noise.
III. Integral control is used to predict future errors.
IV. Loop tuning aims to achieve a balanced

2022

75. Match the CAN bus frame types in List I with their descriptions in List II:

List I: (CAN Bus Frame Types)

P. Data Frame
Q. Remote Frame
R. Error Frame
S. Overload Frame

List II: (Descriptions)

1. Transmitted by a node detecting a bus error
2. Requests data from another node
3. Delays the next frame transmission
4. Carries actual payload information

(A) P-3, Q-1, R-4, S-3
(B) P-2, Q-1, R-4, S-3
(C) P-4, Q-2, R-1, S-3
(D) P-3, Q-4, R-2, S-1

2011

76. Compared to an exclusive-OR (XOR) gate, an exclusive-NOR (XNOR) gate yields a high output when:

(A) Only one single input channel transitions to a high state.
(B) Inputs are in the same state.
(C) The active input channels are held in completely different states.
(D) It is physically and logically impossible for XNOR to output a high signal.

2002

77. The relationship between a microcontroller's clock speed and its instruction execution rate is:

(A) Directly proportional, based on machine cycles.
(B) Inversely proportional, meaning higher speeds yield slower execution rates.
(C) Completely and unconditionally independent of any internal hardware timing.
(D) Permanently fixed at exactly one completed instruction per ten clock ticks.

2004

78. What causes the Program Counter (PC) in a microcontroller to change non-sequentially?

(A) Continuous execution of a basic data movement command.
(B) Explicitly clearing a CPU general purpose register file.
(C) Execution of a Jump or Branch.
(D) Directly reading a continuous external analog input signal.

2014

79. Identify the INCORRECT statement regarding assembly language programming for microcontrollers:

(A) It uses an assembler to convert mnemonic source code into binary machine code.
(B) It provides programmers with direct control of CPU registers and memory.
(C) It utilizes human-readable mnemonics to represent underlying binary machine instructions.
(D) It is completely independent of the specific underlying processor architecture.

2008

80. A microcontroller timer configured in capture mode is typically used to:

(A) Generate an extremely stable and continuous DC reference voltage.
(B) Perform massive bulk erasure operations on internal flash memory blocks.
(C) Measure external pulse widths.
(D) Directly source current to drive a multi-segment alphanumeric LCD display.

2002

81. Consider the following statements regarding PLC CPU components:

I. The arithmetic logic unit (ALU) stores the program on a hard drive.
II. The processor controls the scan cycle execution.
III. Battery-backed RAM is never used in modern PLCs.

Which of the above statements are INCORRECT?

(A) I and II
(B) II and III
(C) I and III
(D) I, II and III

2019

82. Which of the following is NOT typically a function of a PLC's discrete I/O module?

(A) High-voltage electrical signal isolation protection
(B) Dynamic input-to-logic voltage level conversion
(C) Real-time channel status indication via on-board LEDs
(D) Analog-to-Digital conversion

2016

83. What is the most appropriate countermeasure for mitigating electrical noise in PLC signal wiring?

(A) Using shielded twisted-pair cables and

Downloaded from www.pdf.tube

2017

102. Which architecture specifically allocates a single bus for both data and instruction memory fetches?
(A) Harvard
(B) ARM Cortex-M
(C) RISC-V with separate caches
(D) Von Neumann

2012

103. Consider the following statements regarding a microcontroller's ALU:
I. It performs addition and subtraction.
II. It executes logical bitwise operations.
III. It handles analog-to-digital conversions.
IV. It interacts directly with the working registers.
V. It stores the main C program logic.
Which of the above statements are correct?
(A) I, II, III and V
(B) I, II and IV
(C) I, III and V
(D) II, IV and V

2004

104. Which language is generally considered low-level and highly specific to a microcontroller's instruction set?
(A) Python scripting language
(B) Java object-oriented
(C) Assembly
(D) C++ language

2007

105. Under which classification does a microcontroller's Watchdog Timer belong?
(A) Non-volatile memory storage
(B) High-speed arithmetic logic
(C) Continuous analog processing
(D) System safety peripheral

2023

106. What can be inferred if a PLC scan cycle time exceeds the maximum allowed watchdog limit?
(A) A watchdog fault occurs, halting the PLC to ensure safety.
(B) The processor automatically optimizes the program execution speed.
(C) The communications interface increases its transfer rate.
(D) The memory mapping system dynamically expands to accommodate the logic.

2012

107. What is the primary reason for using an analog PLC input module instead of a discrete module?
(A) The need to interface with high-voltage AC electrical lines.
(B) The need to measure continuously variable physical quantities.
(C) The requirement to switch heavy-duty industrial motors.
(D) The requirement to read basic ON/OFF sensor states.

2012

108. The concept of "sinking" in PLC I/O implies that the module or device:
(A) Actively sources DC voltage to the external load.
(B) Provides a path to ground (common) for the connected circuit.
(C) Inverts the analog measurement signal.
(D) Generates a standardized 4-20 mA current output.

2019

109. Identify the INCORRECT pair regarding relay logic elements:
(A) Normally Closed Contact - Passes logic when energized
(B) Coil - Represents an output device
(C) Normally Open Contact - Blocks logic when de-energized
(D) Rung - A horizontal line representing a logic equation

NODIA

2017

110. Identify the CORRECT pair regarding PLC timer instructions:
(A) TOF - Timer Off Delay: Starts timing when rung condition goes true
(B) RTO - Retentive Timer On: Resets automatically on rung false
(C) TON - Timer On Delay: Starts timing when rung condition goes true
(D) RES - Reset: Starts an RTO timer

2015

111. What is a key advantage of defining tags instead of using absolute memory addresses in modern PLCs?
(A) Tag-based systems significantly reduce CPU execution speeds.
(B) Using tags strictly limits the maximum size of the user program.
(C) Tags completely eliminate the need for any internal memory allocation.
(D) Tags improve program readability and simplify memory management.

a central control room
Q. Installed in harsh, distributed environments near field equipment
R. Initiates polling requests to coordinate communication across multiple field sites
S. Interfaces directly with physical sensors and control actuators

List II: Components
1. Master Terminal Unit (MTU)
2. Remote Terminal Unit (RTU)

(A) P-2, Q-1, R-2, S-1
(B) P-1, Q-1, R-2, S-2
(C) P-1, Q-2, R-1, S-2
(D) P-2, Q-2, R-1, S-1

2007

151. Compared to Boolean OR logic, the Boolean AND logic is mathematically analogous to:
(A) Standard addition
(B) Multiplication
(C) Signed subtraction
(D) Floating division

2018

152. Under which classification does the ALU belong within a microcontroller?
(A) Non-volatile memory storage
(B) External input/output peripheral
(C) Central Processing Unit (CPU)
(D) Clock generation circuitry

2006

153. Consider the following statements regarding microcontroller architecture:
I. Flash memory is highly volatile.
II. An oscillator is required to step execution.
III. External interrupts bypass the ALU entirely without software.
IV. General-purpose registers are part of SRAM.
V. Harvard architecture uses a single unified bus.

Which of the above statement(s) is/are INCORRECT?
(A) II, III and IV
(B) I, II and V
(C) I, III and V
(D) I, IV and V

2007

154. Which of the following is NOT a standard data addressing mode in microcontroller CPU architectures?
(A) Immediate addressing
(B) Register direct addressing
(C) Register indirect addressing
(D) Hard-disk sector addressing

2004

155. What inference can be made if a microcontroller's I/O port data direction register is set to all zeros (assuming 0 = input)?
(A) The port pins are actively sourcing maximum current to drive external loads.
(B) The port pins are configured as inputs, typically in a high-impedance state.
(C) The port is configured to output high-frequency pulse-width modulated (PWM) signals.
(D) The internal pull-down transistors are disabled and the pins are hardwired to VCC.

2016

156. What is the definition of "PLC Memory Types" regarding program retention?
(A) Volatile RAM is used to permanently store the operating system and user program without battery backup.
(B) Non-volatile memory, such as Flash or EEPROM, retains the user program during power loss.
(C) Read-Only Memory (ROM) is dynamically modified by the CPU during each execution scan.
(D) High-speed cache memory is utilized to archive real-time SCADA trend logs.

2021

157. A sinking PLC input module must be paired with:
(A) A sourcing field device.
(B) A sinking field device.
(C) A dry-contact switch connected to ground.
(D) An isolated AC-to-DC converter.

2004

158. Which component is fundamentally relied upon for optical isolation in PLC I/O circuits?
(A) Electromechanical relay
(B) High-frequency transformer
(C) Optocoupler
(D) Non-polarized capacitor

2023

159. The fundamental concept of ladder logic is based on reading rungs:
(A) Bottom to top, right to left.
(B) Along a continuous diagonal.
(C) Concurrently in random order.
(D) Left to right, top to bottom.

Click Here to Buy book on Amazon

2017

122. In a CAN bus network, what can be inferred if a node transmits a dominant bit while simultaneously reading a recessive bit from the bus?
(A) A physical bus fault has occurred.
(B) The transmitting network node has successfully won the current arbitration phase.
(C) The affected node will immediately perform a hardware shut down and disconnect.
(D) The universal CAN bus physical standard operates completely normally in this state.

2023

123. Which component is MOST appropriate for interfacing physical world temperatures to a computer-based control system?
(A) Multi-purpose benchtop digital multimeter
(B) Thermocouple with a signal conditioner
(C) High-power variable frequency motor drive
(D) Standard shielded RS-232 serial interface cable

2011

124. Under which classification does an HMI panel on a factory floor generally belong?
(A) Physical analog field sensor device
(B) Local operator interface
(C) Central supervisory Master Terminal Unit
(D) Relational database historian server software

2013

125. Match the RTU components in List I with their descriptions in List II:
List I: (RTU Components)
P. CPU / Microprocessor
Q. Communication Interface
R. I/O Modules
S. Power Supply
List II: (Descriptions)
1. Converts mains AC to required DC levels
2. Processes incoming data and executes local logic
3. Connects physical sensors and actuators
4. Transmits telemetry data to the MTU
(A) P-2, Q-4, R-3, S-1
(B) P-4, Q-2, R-1, S-3
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-3, R-2, S-4

2014

126. What is an advantage of programmable controllers over hardwired relay logic regarding space?
(A) Hardwired relay logic has a smaller footprint than a PLC.
(B) PLCs require external liquid cooling systems that consume space.
(C) PLCs significantly reduce the required control panel footprint.
(D) PLCs must be housed in separate, isolated server rooms.

2024

127. Which of the following is NOT a fundamental feature of the Von Neumann architecture?
(A) Single shared memory space
(B) Fetch and execution cannot occur simultaneously for different memory types
(C) Used in many general-purpose microprocessors
(D) Physically separate memory buses for data and code

NODIA

2024

128. It is a fact that microcontroller general-purpose registers are used to:
(A) Store the bootloader program permanently.
(B) Provide secure non-volatile storage for configuration parameters.
(C) Hold temporary data for ALU access.
(D) Supply high-power output current directly to external actuators.

2004

129. What is the definition of "Assembly Language" in microcontroller programming?
(A) A highly structured high-level object-oriented syntax language.
(B) A low-level language using mnemonics.
(C) A purely visual and diagrammatic programming software interface.
(D) A highly specialized purely graphical ladder logic editor tool.

2003

130. The concept of an "Interrupt Service Routine" (ISR) involves:
(A) Permanently running the main background application loop.
(B) Halting the system clock to reduce total power consumption.
(C) Resetting the program counter to the start of memory.
(D) Halting the main program execution temporarily to handle a specific event.

2016

131. Consider the following statements regarding PLC architecture:
I. The CPU handles mathematical calculations.

2015

112. Compared to the LES (Less Than) instruction, the LEQ instruction in PLC logic evaluates to true when:
(A) Source A is strictly less than Source B
(B) Source A is strictly greater than Source B
(C) Source A is less than or equal to Source B
(D) Source A is greater than or equal to Source B

2015

113. The relationship between an MCR (Master Control Relay) instruction and its programmed zone is:
(A) The active MCR instruction reverses the logic state of all rungs in its zone.
(B) The MCR dictates whether outputs within its zone can be energized.
(C) The MCR instruction permanently deletes the zone logic from memory.
(D) The MCR converts discrete input states to analog values within its zone.

2014

114. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): The MOV instruction in a PLC alters the original data in the source register.
Reason (R): Data manipulation requires clearing the source address to prevent memory overflow.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) Both A and R are false.
(D) A is true but R is false.

2023

115. Which of the following is a NEGATIVE consequence of programming too many continuous sequencer steps without transition logic?
(A) The sequence may advance across multiple steps in a single scan.
(B) The memory array holding the sequencer steps becomes corrupted.
(C) The CPU temperature rises significantly.
(D) The user program memory is automatically formatted by the controller.

2014

116. It is a fact that analog D/A converters in PLCs typically scale digital values into:
(A) High-voltage industrial 120V AC signals
(B) Discrete ON/OFF binary states
(C) Proportional analog voltage or current signals
(D) Serialized Modbus RTU data packets

2007

117. How is PID "Derivative action" defined in terms of error response?
(A) It provides output proportional to the error rate of change.
(B) It continuously applies control output proportional only to the accumulated historical sum of past errors.
(C) It completely ignores the present active error value and applies a fixed pre-determined output current.
(D) It provides instantaneous control output based strictly on the current present error magnitude itself.

2018

118. Which network topology connects nodes sequentially in a closed loop?
(A) Star topology
(B) Bus topology
(C) Mesh topology
(D) Ring topology

2012

119. The fundamental concept of the HART protocol's digital modulation is based on:
(A) Amplitude Modulation (AM)
(B) Frequency Shift Keying (FSK)
(C) Pulse Width Modulation (PWM)
(D) Phase Shift Keying (PSK)

2004

120. What is the reason for a HART multidrop network operating at a fixed 4 mA analog current?
(A) The physical transmission wire is completely broken.
(B) The master controller is incapable of reading currents above 4 mA.
(C) Devices share the loop and communicate digitally using fixed current.
(D) The power supply is failing under peak load conditions.

2019

121. By eliminating master-slave polling, which communication model does Foundation Fieldbus often employ for time-critical data?
(A) Deterministic Token Ring exclusively
(B) Legacy Point-to-Point analog loops
(C) Standard CSMA/CD access protocols
(D) Publisher-Subscriber

Downloaded from www.pdf.tube

values.
(B) Converting serial digital packets into parallel frequency signals.
(C) Filtering high-frequency electromagnetic noise from digital lines.
(D) Modulating pulse-width outputs to drive high-current AC loads.

2017
142. Consider the following statements regarding PLC PID implementation:
I. PID tuning parameters are often stored in dedicated data blocks.
II. A PLC cannot execute PID loops; only dedicated DCS systems can.
III. The PID instruction calculates the manipulated variable (MV) output.
IV. Process variable (PV) is typically read from an analog input.
Which of the above statement(s) is/are correct?
(A) I, III and IV
(B) I, II and IV
(C) II and III only
(D) I, II and III

2005
143. Which is a negative consequence of using a simple bus topology in industrial PLC networking?
(A) It requires redundant power supplies at every node on the bus segment.
(B) It necessitates active star couplers for every network drop.
(C) It requires complex token-passing scheduling for message routing.
(D) A single trunk line break can disrupt communication to downstream devices.

2004
144. In a 4-20 mA loop, what current value typically represents the zero percent (0%) measurement range of a sensor?
(A) 0 mA
(B) 4 mA
(C) 12 mA
(D) 20 mA

2008
145. What is the most appropriate description of a HART-enabled field device?
(A) A pneumatic actuator operating strictly on 3–15 psi air pressure.
(B) An instrument supporting simultaneous analog and digital communication.
(C) A dedicated high-speed optical encoder transmitting pure gray code.
(D) A wireless-only sensor operating on high-frequency microwave channels.

NODIA

2014
146. The concept of "Network Topology" in Fieldbus systems refers to:
(A) The signal encoding standard used to modulate digital packets.
(B) The grounding scheme applied to eliminate shield currents.
(C) The specific software protocol used for remote programming.
(D) The physical or logical layout of the network stations and links.

2019
147. What causes the non-destructive bitwise arbitration in CAN bus?
(A) Dominant bits (0) overriding recessive bits (1) on the physical medium.
(B) A central arbiter node assigning dynamic transmission time slots.
(C) The automatic detection and rejection of duplicate packet headers.
(D) A token passing mechanism that sequentially polls each node.

2007
148. Identify the correct pair of data acquisition components and their functions:
(A) Transducer - Translates serial digital data packets into relational databases.
(B) Multiplexer - Divides a single physical input signal into multiple isolated DC power rails.
(C) Signal Conditioner - Amplifies, filters, or isolates raw sensor signals.
(D) Actuator - Detects physical process variables and converts them to low-voltage signals.

2018
149. An advantage of integrating SCADA software with an enterprise relational database is:
(A) It enables historical trending, long-term archiving, and business analytics.
(B) It eliminates the need for field-level programmable logic controllers.
(C) It automatically tunes PID loop coefficients across the network.
(D) It replaces physical analog input cards with virtual memory registers.

2014
150. Match the MTU/RTU characteristics with their corresponding system component:
List I: Characteristics
P. Serves as the primary master host located in

system response without excessive oscillation.

Which of the above statements are correct?

(A) I, III and IV
(B) II, III and IV
(C) I and IV
(D) I, II and IV

2013

93. What is a primary cause of packet collisions in industrial communication networks utilizing CSMA/CD?

(A) Multiple nodes transmitting on a shared medium simultaneously.
(B) Strict enforcement of deterministic token passing protocols.
(C) Centralized master-controlled polling configurations on the bus.
(D) Physical severance of the primary and redundant network cables.

2011

94. Compared to a 0-10V signal, what is an advantage of a 4-20 mA current loop?

(A) It is less susceptible to voltage drops over long cable runs.
(B) It requires significantly more power.
(C) It cannot be used with microcontrollers.
(D) It inherently transmits digital HART data without a modem.

2014

95. Which of the following is a factual characteristic of the HART protocol?

(A) It operates exclusively on non-licensed wireless bands.
(B) It can only perform basic read operations, preventing configuration writes.
(C) It requires abandoning legacy analog current loops entirely.
(D) It superimposes digital FSK signals on top of the 4-20 mA analog loop.

2006

96. The relationship between devices in a Fieldbus network is primarily:

(A) Point-to-point isolated continuous analog connections.
(B) Centralized hardwired physical relay logic frameworks.
(C) Distributed digital control over a shared bus.
(D) Entirely independent and isolated local process loops.

2007

97. Consider the following CAN bus frames:

I. Extended ID CAN Frame (29-bit) with base ID 0x05
II. Standard ID CAN Frame (11-bit) with ID 0x05
III. Standard ID CAN Frame (11-bit) with ID 0x10

Which of the following represents the correct hierarchical arrangement of CAN bus arbitration priorities, from highest to lowest?

(A) II, I, III
(B) I, II, III
(C) III, II, I
(D) II, III, I

2016

98. By eliminating the necessity for local human operators, which system relies heavily on telemetry to monitor distant pumping stations?

(A) Local HMI
(B) Standalone PID
(C) Hardwired Relay Panel
(D) SCADA

2009

99. Which of the following is NOT typically a software component of a SCADA architecture?

(A) Motor contactor overload relay
(B) Alarm management system
(C) Real-time database / Historian
(D) Graphic display interface

2002

100. What is the best description of an MTU's role in a SCADA system?

(A) It directly measures external physical temperature and pressure variables in the field.
(B) It reliably provides regulated twenty-four volt DC operating electrical power to RTUs.
(C) It issues commands to RTUs and aggregates supervisory data.
(D) It directly opens and closes high-pressure hydraulic field control valves manually.

2002

101. What is the formal definition of a Boolean logic AND function?

(A) The output is true if all inputs are true.
(B) The output transitions to true if any single connected input is true.
(C) The output transitions to true if and only if inputs are in different states.
(D) The output transitions to false if and only if all inputs are held true.

Click Here to Buy book on Flipkart

2017

160. Consider the following events during the execution of a TON instruction:

I. Rung condition goes true
II. Timer accumulates time
III. Accumulated time equals preset time
IV. Done bit is energized

Which of the following represents the correct sequence of these events for the Done (DN) bit to set?

(A) I, III, II, IV
(B) II, I, III, IV
(C) I, IV, II, III
(D) I, II, III, IV

2022

161. Which memory mapping method is primarily used for discrete inputs and outputs in a PLC?

(A) Floating-point representation
(B) Bit-level addressing
(C) Double-word real-number allocation
(D) Structured string array indexing

2018

162. What causes the execution of an EQU (Equal) instruction to evaluate as true?

(A) The accumulators of two different timers both reach their preset values.
(B) Source A is mathematically greater than Source B.
(C) The instruction detects a logical change of state from false to true.
(D) The values of Source A and Source B are mathematically equal.

2012

163. The relationship between the Master Control Relay (MCR) instruction and normal rung execution is:

(A) When the MCR rung is false, non-retentive outputs inside the MCR zone are de-energized.
(B) The MCR instruction overrides retentive timer values and resets them to zero.
(C) The MCR instruction physically cuts the main electrical power grid to the physical I/O chassis.
(D) The MCR zone logic is scanned only once during the initial controller power-up cycle.

2016

164. This question consists of two statements, Assertion (A) and Reason (R). Choose the correct option to describe the relationship between these statements.

Assertion (A): The PLC shift register can track defective products on a moving conveyor line.

Reason (R): A shift register shifts bits representing product status sequentially through a data array synchronized with the conveyor movement.

(A) A is true but R is false.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is false but R is true.
(D) Both A and R are true and R is the correct explanation of A.

2017

165. An advantage of using sequencer instructions (SQO, SQC) over cascaded timers in PLCs is:

(A) Sequencers simplify the programming and troubleshooting of multi-step machine cycles.
(B) Sequencers run independently of the PLC scan cycle to achieve sub-microsecond response.
(C) Sequencers automatically map physical I/O to external enterprise SCADA systems.
(D) Sequencers do not consume any digital memory registers or data blocks.

2013

166. Identify the correct statement regarding D/A (Digital-to-Analog) conversion in PLCs:

(A) It requires an active digital communication connection to an external database.
(B) It is used to measure and digitize voltage or current inputs from field instruments.
(C) It operates by converting frequency inputs to discrete binary numbers.
(D) It converts discrete binary values in the PLC memory into continuous voltage or current output signals.

2014

167. Which term is most appropriate for describing the difference between the PID setpoint and the process variable?

(A) Integral sum
(B) Error
(C) Derivative slope
(D) Bias

2015

168. Compared to traditional point-to-point hardwiring, a PLC field network (e.g., Profinet, DeviceNet) provides:

(A) Greater physical cabling weight and increased installation time.
(B) Complete immunity to all electromagnetic noise without shielding.

Downloaded from www.pdf.tube

2011
244. An advantage of the 4-20mA loop over 0-10V signals in industrial environments is:
(A) It can carry high-speed digital communications without standard network hardware.
(B) It does not require any form of loop power or external current supply.
(C) Greater noise immunity and less signal degradation over long distances.
(D) It utilizes cheaper and smaller diameter wires than voltage circuits.

2010
245. Identify the correct pair of HART command types:
(A) Universal Commands - Functions implemented by all HART-compliant field devices.
(B) Common-Practice Commands - Functions unique to a single manufacturer's product line.
(C) Device-Specific Commands - Commands that must be universally supported across all industrial fieldbuses.
(D) Slot Commands - Methods used exclusively for wireless communications.

2013
246. The concept of "Device Descriptions" (DD) in Fieldbus allows:
(A) The physical mapping and structural support design of network cables.
(B) The network interface to automatically calculate and apply terminating resistance.
(C) The communication master to operate without a defined scan sequence.
(D) The host system to understand and configure a device's specific parameters and variables.

2017
247. The relationship between standard CAN and extended CAN lies in:
(A) The primary baseline physical signaling layer voltage levels.
(B) The identifier length (11 vs. 29 bits).
(C) The operational use of standard CSMA/CD instead of CSMA/CA.
(D) The capability of executing continuous analog data transmission.

2007
248. What inference can be made about a SCADA system utilizing dual-redundant MTUs?
(A) The system is designed for low-cost, non-critical applications.
(B) Communication is limited to localized manual operations on the factory floor.
(C) The system requires high availability and continuous operation in the event of hardware failure.
(D) The remote field units are legacy devices incapable of modern protocols.

2017
249. What causes an RTU to initiate a transmission in a poll-response SCADA architecture?
(A) A power-cycle event at the local remote site.
(B) An internal scheduling clock reaching a predetermined time.
(C) A change in state of a critical local alarm contact.
(D) A specific request or poll command received from the Master Terminal Unit (MTU).

2013
250. Which is a negative consequence of a high polling frequency in a SCADA system over limited bandwidth telemetry?
(A) It can saturate the communication bandwidth, leading to packet drops and delayed critical alarms.
(B) It increases the power consumption of the remote transmitters beyond safe limits.
(C) It corrupts the database tables of the main historian server.
(D) It disables the automated diagnostic routines of the localized controllers.

NODIA

2021
251. Compared to Boolean algebra, ladder logic provides:
(A) Support for multi-dimensional matrix variables on standard logic rungs.
(B) A highly visual, circuit-like graphical representation that matches electrical schematics.
(C) A purely textual, line-by-line programming interface similar to assembly language.
(D) Higher processing speeds by avoiding compiler conversion stages.

2025
252. By eliminating the ALU from a microprocessor, the device would:
(A) Access program instructions faster by avoiding register checks.
(B) Be unable to perform basic arithmetic or logical operations.
(C) Function as a dedicated volatile RAM memory buffer.

registers.

2019

178. By eliminating external clock crystals, many modern microcontrollers use:
(A) Low-frequency ceramic resonators connected to general-purpose I/O pins.
(B) Software delay loops executed dynamically by the arithmetic logic unit.
(C) High-voltage power-line frequency tracking circuits.
(D) Integrated internal RC oscillators.

2004

179. Identify the correct pair regarding microcontroller C programming:
(A) volatile - Prevents compiler optimization for variables that can change outside program flow.
(B) #define - Creates an iterative logic loop that executes during runtime.
(C) int - Declares a high-precision floating-point memory variable.
(D) while(1) - Immediately halts software execution and resets the CPU.

2013

180. The relationship between a microcontroller peripheral and an interrupt vector is:
(A) The peripheral dynamically overrides the system interrupt controller upon execution.
(B) The vector is a temporary hardware register used to store peripheral sensor readings.
(C) The vector contains the memory address of the peripheral's Interrupt Service Routine (ISR).
(D) The interrupt vector is used to buffer data transferred to and from serial peripherals.

2018

181. What is an advantage of a modular PLC over a fixed (shoebox) PLC?
(A) Greater flexibility and scalability to add or mix different I/O and communication modules.
(B) A guaranteed smaller physical footprint regardless of the number of active points.
(C) The complete elimination of an external power supply or backplane requirement.
(D) Lower hardware cost for small systems with low I/O counts.

2006

182. What is the definition of "sinking" in relation to a PLC output module?
(A) The module actively sources positive DC voltage to the connected field load.
(B) The module is designed with a high ingress protection rating for submerged operation.
(C) The module filters out high-voltage transients on AC output channels.
(D) The module provides a low-potential path (common/ground) to complete the circuit for a load.

2016

183. PLC optical isolators typically withstand voltage spikes up to:
(A) 5 to 12 V
(B) 24 to 48 V
(C) 1,500 to 5,000 V
(D) 100,000 to 250,000 V

2023

184. In basic ladder logic, what does an Examine If Closed (XIC) instruction resemble?
(A) A normally closed relay contact
(B) A timer coil
(C) A normally open relay contact
(D) An analog PID block

2014

185. Which is a negative aspect of utilizing purely retentive timers (RTO) without programming a reset (RES)?
(A) The timer begins decrementing its accumulated value when the rung goes false.
(B) The preset timer value is cleared from memory every time the PLC scan finishes.
(C) The PLC CPU will immediately enter a faulted state and stop execution.
(D) The accumulated value is retained even when the rung goes false, preventing the timer from restarting on the next cycle.

2015

186. Which instruction is MOST appropriate to ensure a physical machine stops when an emergency button is pressed, overriding all other logic?
(A) Master Control Relay (MCR) zone de-energization
(B) Jump to Subroutine (JSR) bypass
(C) Timer On Delay (TON) reset
(D) Sequencer Output (SQO) disable

2010

187. Compared to simple relay logic, PLC math instructions (ADD, SUB, MUL, DIV) allow for:
(A) High-speed execution of bit-level logic without memory overhead.
(B) Advanced data computations, sensor scaling, and recipe management.

Click Here to Buy book on Amazon

of critical public infrastructure.
(D) An automatic system shutdown that prevents any potential process damage.

2014
225. By eliminating RTUs from a wide-area SCADA network, the MTU would:
(A) Face reduced processing loads and scan much faster.
(B) Lose its ability to monitor and control remote physical assets.
(C) Reconfigure its internal database to run on local variables.
(D) Convert into a dedicated standalone PLC.

2004
226. Which logic gate is MOST appropriate for creating a parity generator in digital logic?
(A) AND
(B) OR
(C) NOR
(D) XOR

2014
227. An advantage of the Von Neumann architecture is:
(A) A unified memory space that allows flexible allocation between program code and data.
(B) Separate address and data buses that prevent execution bottlenecks.
(C) The ability to fetch data and instructions simultaneously in a single clock cycle.
(D) Built-in hardware security that prevents executing code from data memory areas.

2008
228. The relationship between the ALU and the Status Register in a microcontroller is:
(A) The status register contains the direct inputs that the ALU processes.
(B) The status register routes instructions from program memory to the ALU.
(C) The ALU updates condition flags (such as zero, carry, and overflow) in the status register.
(D) The status register holds the intermediate results of ALU operations.

2025
229. In assembly language, a mnemonic is:
(A) A short, human-readable abbreviation representing a machine instruction.
(B) A hardware logic circuit that decodes instruction registers.
(C) A memory storage segment used for caching fast-access instructions.
(D) A software tool that translates high-level code to assembly.

2001
230. A microcontroller's I/O pins are typically grouped into:
(A) Buses
(B) Nodes
(C) Sectors
(D) Ports

2025
231. What is the definition of a PLC "Image Table"?
(A) A graphical interface representation used on local HMI panels.
(B) A dedicated area of memory that stores the status of physical inputs and outputs during the scan cycle.
(C) An archive database designed for storing history trends.
(D) A hardware-level buffer used during serial communications.

2023
232. The concept of an analog PLC input requires:
(A) An electromagnetic interposing relay.
(B) A high-power digital-to-analog converter.
(C) An Analog-to-Digital Converter (ADC).
(D) A high-speed optical isolator driver.

2011
233. Identify the correct statement regarding PLC optical isolators:
(A) They convert high-frequency analog signals into stable DC currents.
(B) They are used to transmit fiber optic communications between different PLCs.
(C) They physically convert electrical signals into light for long-distance optical routing.
(D) They use light to electrically isolate the internal CPU circuitry from high-voltage field signals.

NODIA

2008
234. What inference can be made about a PLC rung containing two normally closed contacts in parallel?
(A) The output is energized if at least one of the inputs is false.
(B) The output is energized only if both inputs are true.
(C) The circuit implements a logical AND function.
(D) The circuit is permanently open regardless of the input states.

2008

197. Consider the following fields of a CAN data frame:

I. Data Field
II. Arbitration Field
III. CRC Field
IV. Start of Frame (SOF)

Which of the following represents the correct sequence of these fields from start to end?

(A) IV, II, I, III
(B) IV, I, II, III
(C) II, IV, I, III
(D) I, II, III, IV

2018

198. Identify the correct statement regarding Data Acquisition (DAQ) systems:

(A) Standard DAQ platforms are limited to processing binary digital inputs.
(B) Signal conditioning is unnecessary when interfacing with low-level raw thermocouple outputs.
(C) DAQ systems cannot interface with analog sensors without a dedicated SCADA host.
(D) DAQ systems convert physical environmental variables into digital signals for processing and analysis.

2023

199. Which of the following is a negative consequence of poor SCADA HMI design?

(A) Unnecessarily fast operator response times that can lead to manual errors.
(B) Operator alarm fatigue and delayed critical response times.
(C) Increased database query execution latency across the local network.
(D) Frequent physical failures of field-level RTU hardware communication ports.

2011

200. Which component is MOST appropriate to act as the primary communication hub coordinating multiple RTUs over radio telemetry?

(A) Local Human-Machine Interface (HMI) panel
(B) Distributed field-level smart transmitter
(C) Master Terminal Unit (MTU)
(D) Sinking DC digital output module

2012

201. A NAND gate is logically equivalent to:

(A) An OR gate followed by a NOT gate.
(B) An AND gate with its inputs individually inverted.
(C) An XOR gate with all inputs tied together.
(D) An AND gate followed by a NOT gate.

2017

202. What is the definition of a "Microprocessor"?

(A) A central processing unit on a single integrated circuit that requires external memory and peripherals.
(B) A single-chip computer that integrates a CPU, RAM, ROM, and I/O peripherals on one die.
(C) A hardware switch designed to route industrial communications.
(D) A processor optimized solely for high-speed mathematical floating-point operations.

2018

203. A standard 8-bit microcontroller's Arithmetic Logic Unit operates natively on data of what size?

(A) 1 bit
(B) 8 bits
(C) 16 bits
(D) 32 bits

2009

204. Under which classification does the "Immediate Addressing" mode fall in instruction execution?

(A) The instruction operand specifies a memory register holding the target address.
(B) The operand value itself is contained directly within the instruction code.
(C) The operand is fetched dynamically from an external input/output register.
(D) The instruction implicitly refers to the accumulator register.

2004

205. What inference can be made if a microcontroller timer interrupt fires exactly every 1 millisecond?

(A) It can be used to generate a highly stable real-time system tick for scheduler operations.
(B) The external clock source is unstable and causing execution jitter.
(C) The microcontroller is executing code in a low-power sleep state.
(D) The processor's main instruction pipeline is stalled.

2009

206. What causes a PLC scan cycle time to fluctuate significantly?

(A) Variations in the DC power supply voltage feeding the CPU backplane.
(B) Periodic communication dropouts on downstream serial network nodes.
(C) Conditional execution of complex

Downloaded from www.pdf.tube

mathematical instructions and subroutines.
(D) Using normally closed contact instructions instead of normally open contacts.

2006
207. The concept of sourcing and sinking is governed strictly by the flow of:
(A) High-frequency alternating current (AC).
(B) Electromagnetic fields within shielded cable runs.
(C) Direct current (DC) in a closed circuit.
(D) Ground-loop currents in communication shields.

2007
208. Compared to unshielded communication lines, twisted-pair shielded cables in PLCs are utilized for:
(A) Increasing line resistance to prevent electrical short circuits.
(B) Protecting communication conductors from physical crushing forces.
(C) Minimizing electromagnetic interference (EMI) and crosstalk.
(D) Facilitating faster terminal block wiring in high-density installations.

2003
209. An advantage of relay ladder logic is its:
(A) Native support for object-oriented software engineering paradigms.
(B) Intuitive graphical format easily understood by technicians familiar with electrical schematics.
(C) Ability to execute complex database queries without latency.
(D) Complete immunity to syntax and logical programming errors.

2005
210. The relationship between a PLC Counter (CTU) and its Accumulated value is:
(A) The accumulated value is reset to zero at the end of each CPU scan cycle.
(B) The accumulated value decrements on each true-to-false rung transition.
(C) The preset value must always be lower than the accumulated value.
(D) The accumulated value increments on a false-to-true transition of the rung.

2024
211. By eliminating manual memory mapping, tag-based memory organization in modern PLCs allows:
(A) Using descriptive, programmer-defined variable names instead of absolute physical addresses.
(B) Bypassing the compile phase entirely to load logic directly to the CPU.
(C) Decreasing the processing overhead and scan time of the controller.
(D) Running the control program without configuring physical input/output modules.

NODIA

2006
212. Which is a negative outcome of failing to use a limit comparison (e.g., LES, GRT) before executing a DIV instruction?
(A) A sudden reduction in the execution speed of the program scan.
(B) Automatic truncation of high-precision floating-point numbers.
(C) A major processor fault caused by attempting a division-by-zero operation.
(D) A physical hardware failure of the analog input module.

2008
213. Identify the correct pair of PLC flow control instructions:
(A) JSR - Directs program execution to a specified subroutine file.
(B) LBL - Causes the program scan to immediately skip a block of code.
(C) MCR - Unconditionally jumps to the beginning of the program memory.
(D) RET - Resets all internal accumulator registers to their initial states.

2002
214. This question consists of two statements, Assertion (A) and Reason (R). Choose the correct option to describe the relationship between these statements.
Assertion (A): The Bit Shift Right (BSR) instruction is useful for tracking items on a conveyor.
Reason (R): It shifts an array of bits one position to the right upon a false-to-true transition.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011
215. Which instruction is MOST appropriate for checking if a machine step aligns with a predetermined diagnostic pattern?

(A) ADD (Addition)
(B) SQC (Sequencer Compare)
(C) TON (Timer On Delay)
(D) OTE (Output Energize)

2008

216. Analog signal scaling in a PLC typically converts:
(A) Serial data packets into parallel bit structures.
(B) Continuous voltage ranges into corresponding AC frequencies.
(C) Raw digital converter counts into physical engineering units.
(D) Integer values into high-speed pulse-width modulated outputs.

2014

217. What is the definition of "Proportional Band" in PID control?
(A) The frequency spectrum allocated for wireless field device communications.
(B) The physical range of motion allowed by an electronic actuator.
(C) The time required for the integral term to match the proportional action.
(D) The percentage of input error required to produce a full-scale change in the output.

2019

218. A robotic control system often relies on PLC integration via industrial networks to:
(A) Exchange operational status, diagnostic handshakes, and safety interlocks.
(B) Allow the PLC to directly calculate joint trajectory kinematics in real time.
(C) Serve as a web server to display the robot's operating manual to operators.
(D) Power the robot's high-voltage servo amplifiers directly from the I/O rack.

2006

219. The concept of the 4-20mA standard "live zero" refers to:
(A) A floating electrical ground connection on analog input shields.
(B) Using a 4 mA current signal to represent the 0% level, allowing detection of a broken wire.
(C) Active, high-voltage reference used to calibrate thermal sensors.
(D) A software signal used to clear and reset the analog input registers.

2006

220. Under which classification does the HART protocol operate when mixing analog and digital data?
(A) A high-speed, purely digital fieldbus network.
(B) A hybrid analog and digital communication protocol.
(C) A hardwired, relay-based physical interface.
(D) A high-frequency wireless sensor network.

2013

221. What is a direct cause of employing a Fieldbus architecture instead of standard I/O wiring?
(A) Reduced wiring complexity and lower installation costs using a single trunk cable.
(B) An increased requirement for local point-to-point interposing relays.
(C) The loss of individual channel diagnostics on remote sensors.
(D) Slower system-wide processing speeds within the central controller.

2021

222. What inference can be drawn about CAN bus given its arbitration method (CSMA/CR)?
(A) Nodes are assigned fixed, synchronous time slots to avoid collisions.
(B) Every transmitting node must be polled by a central network master.
(C) Messages with lower identifier values win arbitration and proceed without data loss.
(D) Collisions are resolved by having both transmitting nodes stop and back off randomly.

2002

223. Compared to localized PLCs, computer-based industrial control systems excel in:
(A) Basic, non-networked standalone relay replacement logic.
(B) Instantaneous startup times and guaranteed power-fail survival.
(C) Surviving extreme environmental conditions without active cooling or filtration.
(D) Handling large data processing tasks, advanced visualization, and enterprise IT integration.

2006

224. Which is a negative consequence of a compromised SCADA security system?
(A) Improved throughput on industrial Ethernet communication links.
(B) Automatic enabling of secondary backup power systems.
(C) Unauthorized access to and remote control

Click Here to Buy book on Flipkart

(C) Directly switching high-voltage AC circuits without interposing relays.
(D) Decreasing the physical operating temperature of the I/O rack.

2007
188. What inference can be made about a PLC program using a Jump (JMP) instruction continuously in a backward loop?
(A) It acts as an automatic safety interlock to shut down physical outputs.
(B) It can result in a watchdog timer timeout and fault the controller.
(C) It reduces the scan time by bypassing unused output modules.
(D) It simplifies online troubleshooting by isolating the active logic rung.

2004
189. The concept of bitwise manipulation in PLCs is essential for:
(A) Extracting or setting individual status flags packed within a single data word.
(B) Tuning high-precision PID loops for continuous temperature control.
(C) Generating high-speed analog waveforms on physical output modules.
(D) Managing the communication baud rate on industrial serial networks.

2019
190. Under which classification does the SQL (Sequencer Load) instruction fall?
(A) Advanced arithmetic and mathematical calculation
(B) Fundamental bit-level relay contact logic
(C) Array and data handling
(D) Proportional analog channel input scaling

2003
191. What causes quantization error in an analog PLC module?
(A) High-frequency electromagnetic noise induced on unshielded cabling.
(B) A calibration mismatch between the transmitter and the input card.
(C) The phase shift caused by filtering circuits on the analog input.
(D) The approximation of a continuous analog signal into discrete digital steps.

2021
192. What is the definition of "Loop Tuning" in a PID controller?
(A) Re-calibrating the physical transmitter's zero and span settings in the field.
(B) Modifying the polling cycle of the controller's analog input module.
(C) Adjusting the proportional, integral, and derivative coefficients to optimize system response.
(D) Setting up the network communication parameters for the distributed I/O rack.

NODIA

2022
193. Industrial communication interfaces like RS-485 utilize:
(A) Single-ended voltage signaling referenced to a common system ground.
(B) Differential voltage signaling to provide high noise immunity.
(C) High-voltage alternating current waveforms to transmit digital bits.
(D) Multi-mode optical fiber lines to completely eliminate ground loops.

2017
194. In the evolution of industrial signal standards, pneumatics (3-15 psi) were largely replaced by:
(A) 0 to 5 V voltage signals
(B) RS-232 serial links
(C) Hydraulic fluid circuits
(D) 4 to 20 mA current loops

2003
195. What is an advantage of the HART protocol regarding legacy infrastructure?
(A) It allows digital communication signals to superimpose on existing 4–20 mA analog wiring.
(B) It increases the power-carrying capacity of legacy telephone cables.
(C) It enables gigabit-speed Ethernet transmission over unshielded field wires.
(D) It eliminates the need for external DC loop power supplies.

2012
196. By eliminating the necessity for physical wire connections to a central PLC, wireless fieldbus systems primarily risk:
(A) Higher cabling costs due to specialized transmitter antennae.
(B) Severe mechanical wear and tear on the wireless receivers.
(C) Susceptibility to signal interference, packet loss, and security vulnerabilities.
(D) Inability to communicate with standard PLC programming platforms.

2007

235. Under which classification does the Retentive Timer (RTO) operate?

(A) A math instruction that counts accumulated floating-point values.

(B) A timer instruction that retains its accumulated value when the rung goes false and requires a RES instruction to clear.

(C) A hardware register used to log system fault history.

(D) A program control instruction used to skip rungs of ladder logic.

2025

236. What causes a PLC program to access a specific data bit inside a 16-bit word?

(A) Performing an arithmetic division instruction on the target register.

(B) Using bit-level addressing syntax to specify the word and bit position.

(C) The automatic scaling of a continuous analog input channel.

(D) Mapping physical terminal wires to separate I/O modules.

2014

237. Compared to the ADD instruction, the MUL instruction requires:

(A) Larger potential destination limits due to rapid scaling of the product.

(B) Less processing time in the ALU compared to standard addition.

(C) Direct physical connection to high-speed count inputs.

(D) Dedicated math coprocessor hardware in all PLC systems.

2008

238. Which is a negative aspect of excessive use of Jump (JMP) instructions in PLC logic?

(A) It causes physical thermal strain on the controller's processor.

(B) It reduces the scan cycle speed by forcing unused code to run.

(C) It makes the ladder logic difficult to read, debug, and maintain (spaghetti code).

(D) It creates electrical interference on the local network bus.

2008

239. Which PLC instruction is designed to copy data from a source register to a destination register while allowing specific bits to be filtered or ignored?

(A) Copy File (COP)

(B) Masked Move (MVM)

(C) Bit Shift Right (BSR)

(D) Sequencer Load (SQL)

2015

240. What is the definition of a PLC Sequencer (SQO)?

(A) A hardware-level microchip that coordinates peripheral clock cycles.

(B) A multi-pole electromechanical relay used to sequence power phases.

(C) An instruction that controls sequential multi-step operations by stepping through an array of data words.

(D) A communication protocol used to manage priority queues on fieldbuses.

2023

241. Analog signal resolution is determined by:

(A) The physical thickness and resistance of the field copper wiring.

(B) The number of bits used by the Analog-to-Digital Converter (ADC).

(C) The response speed of the optical isolation semiconductor devices.

(D) The maximum current limit of the loop power supply.

2011

242. In PID control, the "Integral Windup" phenomenon occurs when:

(A) The proportional gain is set to zero, disabling the primary loop feedback.

(B) The derivative term responds too rapidly to a step change in setpoint.

(C) A sensor wire breaks, causing the process variable to drop to its lowest limit.

(D) A persistent error causes the integral term to accumulate to its limit because the actuator is fully open or closed (saturated).

2024

243. Which is MOST appropriate for linking PLCs from different manufacturers into a unified factory network?

(A) An open, standardized protocol such as Modbus TCP or EtherNet/IP over industrial Ethernet.

(B) Proprietary, vendor-locked serial communication links.

(C) Individual hardwired point-to-point connections between each PLC's discrete I/O cards.

(D) Parallel bus-sharing interfaces requiring custom microchip development.

NODIA

(C) Reduced cabling requirements and enhanced diagnostic capabilities.
(D) A restriction to communicating only discrete ON/OFF signal states.

2018
169. What is the formal definition of the "HART Protocol"?
(A) High-speed Analog Relay Transmission
(B) Hardwired Automation Routing Technology
(C) Hub and Ring Topology
(D) Highway Addressable Remote Transducer

2004
170. Universal HART commands are:
(A) Supported and implemented by all HART-compliant field devices.
(B) Custom-designed by manufacturers for specific unique hardware functions.
(C) Used only when the device is operated in a point-to-point analog mode.
(D) Restricted to wireless transmission channels.

2018
171. Which organization model describes the OSI 7-layer architecture often referenced in Fieldbus standards?
(A) A standardized layered framework for network protocol design.
(B) A physical cabling standard used exclusively for serial networks.
(C) A hardware standard defining the power ratings of network switches.
(D) An industrial database architecture for storing historical data.

2005
172. What inference can be made about a CAN network utilizing a 120-ohm terminating resistor at each end of the main bus?
(A) The resistors are used to step down the main DC power supply voltage.
(B) They are used to match transmission line impedance and prevent signal reflections.
(C) They are installed to amplify high-frequency carrier signal amplitudes.
(D) The network is configured incorrectly since terminators should only be placed at one end.

2011
173. Which is a negative aspect of implementing complex computer-based control over a standard standalone PLC?
(A) Increased susceptibility to operating system updates, software instability, and IT security threats.
(B) The lack of support for multi-user access or remote graphical user interfaces.`
(C) The inability to execute standard IEC 61131-3 programming languages.
(D) Severe physical constraints on real-time data storage capacity.

2019
174. Under which classification does SCADA primarily operate?
(A) Machine-level deterministic closed-loop control
(B) Embedded micro-level execution
(C) Supervisory level control and data acquisition
(D) Pure analog signal conditioning

2017
175. Match the data manipulation instruction to its corresponding category:
List I: Instructions
P. ADD
Q. MOV
R. JMP
S. AND
List II: Categories
1. Arithmetic
2. Data Transfer
3. Program Control
4. Logical / Bitwise
(A) P-4, Q-2, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-3, Q-4, R-2, S-1

2021
176. What causes a direct cause of applying a Boolean NOT gate to a high (1) signal?
(A) The output is forced into a high-impedance state.
(B) The output voltage is doubled.
(C) The output signal is inverted to a low (0) state.
(D) The output signal remains high (1).

2013
177. The concept of "Harvard Architecture" allows microcontrollers to:
(A) Store data and instructions in a single, unified memory space.
(B) Access instructions and data concurrently using separate memory buses.
(C) Execute operations sequentially by sharing a single data and address bus.
(D) Eliminate the need for any static RAM

Downloaded from www.pdf.tube

(D) Rely entirely on external co-processors to manage bus timing.

2013

253. Under which classification does the Instruction Register (IR) fall within a CPU?
(A) Control unit and decoding circuitry.
(B) General-purpose data registers.
(C) Arithmetic Logic Unit (ALU) hardware.
(D) External address mapping interfaces.

2007

254. In C programming for microcontrollers, manipulating physical I/O pins typically involves:
(A) Invoking SQL database commands inside the main runtime loop.
(B) Calling high-level operating system APIs via Ethernet links.
(C) Writing to specific Special Function Registers (SFRs) mapped to the pins.
(D) Initiating a flash-erase cycle on the program memory block.

2011

255. What is the definition of "Pulse Width Modulation" (PWM) in microcontroller peripherals?
(A) Generating a pure, ripple-free analog DC voltage directly from a pin.
(B) A high-speed serial communication protocol used to link multiple processors.
(C) A memory management scheme used to cache peripheral instructions.
(D) Varying the duty cycle of a constant-frequency square wave to simulate an analog output.

2005

256. The relationship between PLC scan time and input responsiveness is:
(A) A longer scan time increases the speed of detecting input changes.
(B) Scan time has no influence on the delay between physical input transitions and logic execution.
(C) A shorter scan time reduces the latency in detecting and responding to input changes.
(D) System responsiveness is governed solely by the response speed of the output modules.

2010

257. The concept of "solid-state" discrete outputs in PLCs implies the use of:
(A) Mechanical switches with heavy copper contacts.
(B) Semiconductor devices such as transistors or triacs.
(C) Pneumatic micro-valves driven by auxiliary air.
(D) Electromagnetic relays with silver-plated contacts.

2004

258. An advantage of utilizing a dedicated PLC power supply over standard commercial adapters is:
(A) Lower cost and smaller physical dimensions for basic applications.
(B) The ability to output multiple unregulated AC voltages.
(C) Built-in network routing capabilities for direct SCADA connection.
(D) Superior filtering of electrical noise, robust voltage regulation, and tolerance to thermal stress.

2004

259. What inference can be made about a PLC rung that lacks any input instructions but has an output coil?
(A) The output coil is continuously energized during controller RUN mode.
(B) The compiler will refuse to compile an EQU block that references floating-point tags.
(C) The physical output point will cycle on and off at the processor's clock frequency.
(D) The PLC will compile the rung but immediately trigger a runtime watchdog fault.

NODIA

2003

260. What causes a PLC Counter (CTD) to decrement its value?
(A) A true-to-false transition of the rung logic.
(B) A master reset command issued by the CPU operating system.
(C) A false-to-true transition of the rung logic.
(D) The accumulator value of an associated Timer On Delay reaching its preset.

2011

261. Identify the correct statement regarding modern tag-based PLC memory:
(A) Data types and physical addresses are assigned to named tags rather than fixed memory registers.
(B) Variable names are restricted to short, 8-character codes to conserve memory.
(C) Tag-based addressing significantly increases scan time compared to rack-slot-channel addressing.

27. (B) On-chip integration of memory and peripherals
Microcontrollers are optimized for embedded applications by integrating the central processing unit, volatile and non-volatile memory, and key peripherals onto a single silicon chip. This high integration minimizes the physical board space, lowers overall system cost, and reduces design complexity. In contrast, general-purpose microprocessors require separate external chips for memory and basic input-output peripheral interfacing.

28. (B) It employs a load-store architecture.
A microcontroller featuring a dedicated register file next to the arithmetic logic unit typically uses a load-store architectural design. In this model, data must be transferred from the main system memory into these internal registers before any processing can occur. Once completed, the results must be stored back to memory via explicit data transfer instructions.

29. (A) The processor restores the Program Counter and re-enables interrupts.
Executing the return-from-interrupt instruction concludes the execution of an interrupt service routine, causing the CPU to resume the suspended program. The processor automatically pops the saved program counter from the stack, restoring the exact execution address before the interrupt occurred. Simultaneously, this instruction re-enables the global interrupt system to allow future event processing.

30. (C) External Interrupts
External interrupt pins allow microcontrollers to detect and respond to sudden real-world signal changes without continuously running software checking loops. When an external change occurs, hardware immediately alerts the processor to execute the associated interrupt service routine. This hardware-driven detection scheme minimizes processor overhead, which significantly improves system energy efficiency and reduces software response times.

31. (B) I and III
The programmable logic controller scan cycle executes in a strict synchronous order, reading physical inputs before evaluating logic and updating output states. Additionally, the internal image tables are updated at specific phases of the cycle rather than continuously and asynchronously. Therefore, claiming that outputs are written first or that memory updates asynchronously is incorrect regarding standard operations.

32. (C) ON/OFF binary states
Discrete input modules in programmable logic controllers are designed to process binary electrical signals that represent two distinct states: on or off. These digital signals originate from field devices such as limit switches, proximity sensors, pushbuttons, and pressure switches. The module converts these high-voltage external states into low-voltage logic signals used by the processor.

33. (B) To isolate low-voltage logic from high-voltage field wiring
Optical isolators protect the internal processing units of controllers by breaking the direct electrical connection between field wiring and low-voltage digital buses. These components transmit signals using an internal light-emitting diode paired with a photosensitive receiver. This optical gap prevents high-voltage spikes, transient electrical noise, and ground loops from damaging the sensitive central processing circuitry.

34. (D) Normally Open
In industrial electrical and relay logic systems, the abbreviation NO designates a normally open contact state. This mechanical or virtual contact remains disconnected, blocking current flow or logic continuity, as long as its controlling actuator or coil is not energized. When the relay is activated, these contacts close to complete the circuit and pass power.

35. (A) It increases complexity and wastes memory.
Using multiple cascading timers to count events increases program complexity and consumes excessive memory register space within the controller. Standard timer instructions require storage for preset values, accumulated values, and multiple control bits, which is inefficient compared to a single counter instruction. Dedicated counters simplify user code design and optimize processor resource allocation in programming structures.

36. (C) Integer (INT)
Standard memory organization in industrial programmable controllers designates sixteen bits of storage space for the standard integer

Click Here to Buy book on Amazon

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

ANSWERS

1. (B) XOR
The exclusive-OR logic function outputs a high state exclusively when its input signals are at mismatching logic levels. If both input channels receive identical logic states, the resulting output evaluates to a low state. This characteristic makes this logical operation highly effective for difference detection, inequality comparison, and parity generation circuits in digital hardware architectures.

2. (D) Separate memory buses for instructions and data
Harvard processor architecture utilizes physically independent signal pathways and storage spaces for handling machine instructions and operational data. This structural division allows the processing unit to execute instruction fetches and read or write data operations simultaneously. This simultaneous access eliminates the bottleneck associated with shared single-bus structures, which is a key trait in high-performance embedded microcontrollers.

3. (A) Oscillator circuit
The internal timing and synchronous execution of instructions within microcontrollers rely on a steady periodic wave generated by oscillator circuits. This circuitry utilizes external crystals, resonators, or internal resistor-capacitor networks to produce the foundational high-frequency heartbeat. This master clock signal coordinates the exact timing of the arithmetic logic unit, peripheral registers, program counter incrementing, and memory bus operations.

4. (C) Indirect addressing uses a register to hold the memory location of the data.
Indirect addressing schemes utilize a designated register or memory location to store the target address where the actual data resides. Instead of hardcoding the final memory address inside the instruction, the CPU looks up the pointer stored within the register. This dynamic method enables efficient loop processing, array index handling, pointer operations, and variable memory structures in embedded firmware.

5. (A) Hardware interrupts must be triggered by internal software events exclusively.
Hardware interrupts within microcontroller units can be triggered by external signals applied to dedicated physical input pins. Examples include changes in logic levels on pins, external pulse edges, or signals from peripherals such as timers, analog comparators, and serial interfaces. These hardware-level signals suspend the main program execution immediately, allowing the system to react rapidly to external physical processes.

NODIA

6. (D) Reading inputs, executing logic, writing outputs
The operational cycle of a programmable logic controller systematically follows a fixed three-phase sequence to ensure deterministic execution. Initially, the controller reads the physical inputs to update the internal image table. Next, it executes the user-programmed control logic sequentially from top to bottom. Finally, it writes the resulting calculations to update the physical output channels during each loop.

7. (B) The field device acts as a sourcing type, supplying positive voltage to the module.
Sinking input modules are designed to receive current from connected field devices, acting as a path to ground. Consequently, these modules require sourcing field devices that actively supply positive voltage and source electrical current to the input terminals. This complementary arrangement establishes a closed electrical circuit, allowing the controller to detect the status transitions of the connected field sensors.

8. (C) By employing galvanic isolation and noise filtering
Industrial programmable logic controller power supplies safeguard sensitive internal microprocessors by employing galvanic isolation and electronic noise filtering. Galvanic isolation physically separates the high-voltage AC input circuits from the low-voltage DC logic circuits. Simultaneously, noise filtering blocks high-frequency transients, surges, and electrical interference on the power line, ensuring stable operation under harsh environmental conditions.

65. (B) Data is written into the sequencer array at the current step.
Triggering a sequencer load instruction copies current input conditions into a referenced sequencer data file at the active step. This command allows the controller to record manual operations and save sequence configurations during runtime. Rather than hardcoding steps, operators can cycle the equipment manually and load states directly into controller memory for automatic playback.

66. (D) Resolution (e.g., 12-bit, 16-bit)
The resolution of an analog input card, defined by its bit depth, determines the smallest voltage change the converter can measure. For example, a twelve-bit module divides an input range into four thousand ninety-six steps, whereas a sixteen-bit module provides sixty-five thousand five hundred thirty-six steps. Higher resolutions allow finer detection of subtle process variable changes.

67. (A) Continuous closed-loop control
PID control algorithms operate as continuous closed-loop systems, constantly measuring process feedback to adjust system control outputs. By comparing a process variable to a setpoint, the algorithm calculates error and adjusts a control variable, such as a valve position. This feedback loop runs continuously to maintain process setpoints despite external disturbances.

68. (C) PROFIBUS DP - RS-485
PROFIBUS DP networks typically operate over a physical RS-485 serial connection to transfer data across factory floors. This physical standard uses differential signaling over shielded twisted-pair cables, which provides high noise immunity and supports long distances. This combination ensures reliable communications in high-noise industrial environments, connecting master controllers with remote I/O blocks.

69. (A) The 4 mA offset detects broken wires.
The four-to-twenty milliampere loop has become the industrial standard because the four-milliampere live zero offset enables open-circuit fault detection. In older zero-to-twenty milliampere loops, an actual physical wire break was indistinguishable from a minimum process measurement. With the four-milliampere standard, any drop to zero milliamperes is immediately recognized as a loop wire fault.

70. (D) It requires dedicated point-to-point wiring for each device.
A primary disadvantage of point-to-point HART configurations compared to multidrop networks is the need for dedicated cabling from each device to the controller. While multidrop configurations share a single cable, point-to-point wiring increases installation costs, labor, and control cabinet space. Each individual current loop requires its own analog input channel, limiting overall scaling flexibility.

71. (B) Different brands of devices work on the same bus.
Interoperability within Fieldbus architectures allows instruments from different manufacturers to coexist and communicate on a single network. By adhering to open, standardized digital protocols, diverse devices can exchange process data and diagnostics without requiring specialized translation gateways. This standardization provides engineers with flexibility when selecting and integrating instrumentation from multiple vendors.

72. (C) 29-bit ID
The Extended CAN frame standard, defined under the CAN specification, expands the message identification header to a twenty-nine-bit identifier. This structure combines the standard eleven-bit base identifier with an eighteen-bit identifier extension. This larger addressing space supports complex vehicle and industrial systems, allowing thousands of unique message priorities on the same network.

73. (D) Data Acquisition (DAQ)
Data acquisition involves measuring physical phenomena, such as temperature, pressure, flow, or force, and converting these analog readings into digital signals. The system uses sensors to output voltages, conditions these signals, and then digitizes them using analog-to-digital converters. This digital data is then analyzed and logged by computer software for process analysis.

74. (A) A field device interfacing sensors via telemetry.
A remote terminal unit is a microprocessor-controlled field device designed to interface with

Downloaded from www.pdf.tube

18. (D) All devices connect directly to a central hub or switch.
A star network layout organizes communication pathways by routing individual connections from every industrial device to a single centralized junction. This central device, usually an ethernet switch or hub, acts as the primary router for data traffic. If an individual network cable fails, only the associated node is disconnected, preventing complete network outages across other active nodes.

19. (A) Inherent detection of a broken wire
The use of an elevated zero level in four-to-twenty milliampere transmission systems provides an inherent diagnostic advantage for industrial monitoring. When a physical wire breaks or a sensor loses power, the loop current drops to absolute zero. This zero milliampere state allows the controller to differentiate immediately between a true minimum process reading and a signal line fault.

20. (C) The analog current is fixed at 4 mA using only digital data.
In multidrop communication mode, multiple instruments are wired in parallel on a single loop, requiring digital polling for data exchange. To enable this network arrangement, the analog current of each connected device is locked at a constant four milliamperes. This constant current prevents conflicting analog signals, ensuring all process variables are transmitted purely through superimposed digital frequency modulation.

21. (A) It exclusively utilizes unshielded twisted pair wiring.
Fieldbus architectures support diverse physical media, including shielded twisted pair cables, fiber optic links, and wireless transmission channels, depending on environmental demands. Shielding is highly recommended in industrial installations to mitigate intense electromagnetic interference from nearby motors and power cables. Therefore, limiting the network to unshielded twisted pair wiring does not represent a fact of this design.

22. (D) CSMA with Collision Resolution (CSMA/CR)
The controller area network uses carrier sense multiple access with collision resolution to manage data bus access without data corruption. When multiple nodes transmit simultaneously, they compare their frame identifiers bit by bit. Dominant bits overwrite recessive bits on the wire, allowing the highest-priority message to proceed uninterrupted while lower-priority nodes stop transmitting immediately.

23. (B) Analog-to-Digital Converter
Data acquisition hardware relies on an analog-to-digital converter to transform continuous physical signals into discrete numerical representations. This electronic component samples the varying input voltage at specific intervals and rounds it to the nearest binary value. The resulting digital data is then transferred to a central processor for software-based analysis, monitoring, and storage.

24. (C) It performs supervisory control over geographically distributed assets.
Supervisory control and data acquisition systems are designed to manage large-scale networks of industrial assets scattered over wide geographic areas. While local controllers govern high-speed operations within a single machine or facility, this supervisory system aggregates data and sends coordination commands across wide-area communications, linking multiple distant field stations to a central control room.

NODIA

25. (A) P-3, Q-1, R-2, S-4
A SCADA system incorporates diverse components serving specialized roles:
P. The master terminal unit operates as the central host controller to coordinate the telemetry network.
Q. Remote terminal units connect directly to local instrumentation to acquire physical input and output data.
R. Human-machine interfaces provide visual screens for operators to monitor operations.
S. Communication lines transmit data.

26. (C) NAND
The NAND gate is classified as a universal logic element because any boolean function can be realized using only combinations of this gate. By configuring multiple NAND gates, designers can easily construct basic functions such as AND, OR, NOT, and XOR. This versatility simplifies digital integrated circuit design and standardizes fabrication processes in manufacturing semiconductor logic chips.

46. (C) A digital, multi-drop link among intelligent devices.
Fieldbus networks establish digital, multidrop communication links that connect multiple smart field instruments to a central controller over a single cable. This digital bus replaces traditional point-to-point analog wiring loops, reducing installation costs and labor. This design allows bi-directional communication, enabling the transfer of both process measurements and device diagnostics.

47. (D) Wired-AND logic at the physical layer.
The physical layer of a controller area network operates on a wired-AND logic structure over differential communication lines. In this configuration, a dominant bit represents a logical zero, while a recessive bit represents a logical one. If any node drives the bus dominant, the physical lines transition to this state, overwriting any recessive states transmitted by other nodes.

48. (C) Aliasing will occur, distorting the recorded signal.
Sampling an analog signal at a rate below the Nyquist threshold violates sampling theorem requirements, preventing accurate reconstruction. This under-sampling causes high-frequency signal components to appear as lower-frequency ghosts, a phenomenon known as aliasing. Once aliasing occurs, the original waveform is distorted, making it impossible to separate the true signal from the digital artifacts.

49. (B) Real-time visualization and alarm management.
Supervisory control software excels in industrial monitoring by providing real-time process visualization and automated alarm management. These interfaces display dynamic plant conditions graphically, allowing human operators to quickly evaluate system status. When process thresholds are breached, the alarm system immediately flags critical deviations, enabling rapid response to abnormal operational events.

50. (D) A distributed SCADA system
A telemetry layout where remote terminal units communicate directly with a central master terminal unit defines a distributed supervisory control and data acquisition system. This architecture is typically deployed across extensive geographical areas, such as water pipelines or electrical grids. This structure centralizes data monitoring and coordination without relying on local plant controllers.

51. (A) Ladder rungs represent Boolean equations.
The horizontal rungs in a ladder logic diagram are direct graphical representations of boolean equations. Series contacts act as logical AND conditions, while parallel contacts represent logical OR structures, driving the output coil at the end of the rung. Therefore, ladder logic translates mathematical logic equations into an intuitive format for maintenance and engineering personnel.

52. (C) System on a Chip (SoC) / Embedded system
A semiconductor chip integrating a central processing unit, volatile and non-volatile memory, and input-output interfaces represents a system-on-a-chip or embedded system. This consolidated architecture provides a self-contained computing platform on a single piece of silicon. This layout minimizes external components, reduces power consumption, and is highly optimized for dedicated real-time control functions.

53. (A) I, II, III and IV
Most microcontrollers contain internal clock generators, such as RC oscillators, to provide clock signals. Within the processor, the ALU performs math and logic, flash memory holds executable code, and volatile SRAM stores temporary runtime data. Additionally, watchdog timers act as safety devices, resetting the system if the software hangs in a fault loop.

54. (D) 64-bit virtual addressing
Basic eight-bit microcontrollers support addressing modes like immediate, direct, and indexed to access memory space within their small registers. However, sixty-four-bit virtual addressing is not found in these small devices, as they lack the hardware support for virtual memory. This complex addressing scheme is typically reserved for high-performance processors in desktop computers.

55. (B) They can generate PWM signals.
On-chip hardware timers can be configured as pulse-width modulation generators to control external devices. By comparing timer register counts to a user-defined threshold, the output pin toggles at precise intervals, adjusting the duty cycle. This feature is widely used to regulate

Click Here to Buy book on Flipkart

data type. This sixteen-bit structure allows the representation of signed numeric values ranging from negative thirty-two thousand seven hundred sixty-eight to positive thirty-two thousand seven hundred sixty-seven. This format is widely used for counter values and basic analog readings.

37. (A) Multiply two source values and store the result.
The multiplication instruction in programmable logic controllers is a mathematical block that calculates the product of two specified source variables. Upon execution, the central processing unit retrieves the values from both source addresses, multiplies them, and saves the output into a designated destination register. This mathematical function is standard for scaling sensor inputs and executing process calculations.

38. (D) It reduces execution time by running code only when called.
Subroutines improve controller efficiency by keeping specific segments of program code unexecuted until they are explicitly called by the main program logic. Instead of scanning inactive or seasonal logic during every loop, the controller skips these subroutines entirely when their call conditions are false. This selective execution optimizes processor scan time and overall system resources.

39. (B) BSL - Shifts bit arrays to the left
The bit shift left instruction is a standard data manipulation command designed to shift bits sequentially through an array or register. With each false-to-true transition of its enabling logic, the bits move one position to the left, inserting a new bit at the starting index. This command is widely used for tracking items on conveyor belts.

40. (C) SQI - Sequencer Integral
Programmable logic controllers support standard step-sequence commands, including sequencer output to drive channels, sequencer compare to evaluate inputs, and sequencer load to record step data. The abbreviation SQI does not stand for a sequencer integral function, which is non-existent in PLC programming languages. Instead, sequential processes rely on standard PID instructions for loop integration.

41. (D) Quantization-free infinite precision
Analog-to-digital converters in industrial controllers convert continuous voltages into discrete digital steps, introducing rounding errors known as quantization noise. Because these devices rely on finite bit depths to represent values, they cannot provide infinite precision. The physical conversion process is inherently limited by resolution steps and sampling rates, making quantization-free infinite precision impossible in digital controllers.

42. (C) II, III and IV
Effective loop tuning requires balancing the proportional, integral, and derivative parameters to optimize transient response and stability. The integral term eliminates persistent steady-state offset, while the derivative term responds to the rate of error change to prevent overshoot. However, excessively increasing the proportional gain does not stabilize the process; instead, it typically causes severe oscillation and system instability.

43. (B) It operates at lower transmission speeds.
Modbus RTU networks operating over physical RS-485 serial connections have significantly lower transmission speeds than modern ethernet networks. While Ethernet/IP transmits data at speeds up to hundreds of megabits per second, RS-485 serial lines are typically limited to lower kilobit-per-second rates. This lower bandwidth limits real-time data update rates in complex multi-node automation systems.

44. (B) The controller detects a wire fault.
In four-to-twenty milliampere current loops, a signal of four milliamperes represents the minimum calibrated process value. If the current drops to zero milliamperes, it falls below this valid minimum limit. The controller interprets this drop as an electrical open-circuit fault or wire break, triggering diagnostics to halt the process and alert operators.

45. (A) Read primary variable
Universal commands in the Highway Addressable Remote Transducer protocol are basic instructions that must be recognized and supported by all HART-compatible field devices. Reading the primary process variable is a fundamental universal command, ensuring standardized data retrieval across different manufacturers. More specific actions, such as sensor calibration, are categorized under common-practice or device-specific command levels.

Downloaded from www.pdf.tube

(D) Tag systems require specialized gateways to communicate with external HMI platforms.

2021

262. Which is a negative outcome of using an EQU instruction instead of a limit comparison (e.g., LES, GRT) for floating-point values?
(A) The CPU will refuse to compile an EQU block that references floating-point tags.
(B) The EQU instruction will always evaluate as true due to floating-point truncation.
(C) The instruction causes an arithmetic overflow in the internal math accumulator.
(D) Precision and rounding errors may prevent two values from being exactly equal, causing the instruction to evaluate as false.

2025

263. The relationship between a PLC main program and a subroutine is:
(A) The main program is nested within the first subroutine of the execution file.
(B) The main program uses call instructions to execute subroutines for modular or repetitive tasks.
(C) Subroutines execute automatically in parallel with the main program without call instructions.
(D) Subroutine rungs are scanned only when the controller detects an internal software fault.

2012

264. Which instruction is MOST appropriate for resetting a large contiguous block of memory to zero?
(A) OTE (Output Energize)
(B) ADD (Addition)
(C) FLL (File Fill)
(D) TOF (Timer Off Delay)

2012

265. Compared to standard bit logic, matrix operations in PLCs allow:
(A) Mapping physical terminal points to virtual memory registers.
(B) Directly driving high-current AC loads without interposing relays.
(C) Decreasing execution scan time by disabling logic rungs.
(D) Performing logical or comparison operations on entire arrays of data words simultaneously.

2014

266. Under which classification does "signal scaling" in PLCs belong?
(A) Analog data manipulation
(B) Standard discrete channel input processing
(C) Fundamental electromagnetic relay coil logic
(D) High-level communication network packet routing

2009

267. By eliminating the Integral term in a PID controller (making it a PD controller), the system loses its ability to:
(A) Respond to rapid rate-of-change deviations.
(B) Eliminate steady-state error (offset).
(C) Stabilize highly oscillatory, fast-responding processes.
(D) Interface with remote digital communication networks.

2018

268. In an industrial communication network, the term "baud rate" refers to:
(A) The physical propagation delay of a signal over a specified cable distance.
(B) The rate at which the communication channel transitions between signal states.
(C) The maximum number of active logical nodes allowed on a network segment.
(D) The data density of a frame excluding overhead and parity bits.

2014

269. The concept of "Smart Instruments" in the context of HART and Fieldbus means the devices can:
(A) Perform self-diagnostics, calibration, and bidirectional digital communication.
(B) Operate on wireless energy harvested from local electromagnetic fields.
(C) Run control logic loops entirely independent of electrical power sources.
(D) Automatically splice and repair damaged physical cabling.

NQDIA

2004

270. What is the definition of "Multidrop" in HART networks?
(A) Dropping weak or corrupt digital packets to maintain loop communication integrity.
(B) Connecting a single transmitter to a dedicated pair of wires for analog monitoring.
(C) Connecting multiple field devices in parallel on a single wire pair, with communication occurring entirely via digital polling.
(D) Distributing local network drops to various levels of a manufacturing facility.

****

motor speeds, control LEDs, and generate analog voltages in embedded systems.

56. (C) Scan time
The scan time specifies the duration required for a programmable logic controller to complete one full cycle of operations. This cycle includes reading all physical input channels, executing the user program from top to bottom, and writing results to physical outputs. Shorter scan times allow for faster responses to transient industrial process changes.

57. (D) The module supplies voltage to the load.
A sourcing output module actively supplies positive DC voltage to the connected external load when activated. In this electrical circuit configuration, current flows from the output terminal, through the load, and returns to ground. Sourcing outputs are paired with sinking field devices, which complete the path to the common return.

58. (A) Preventing electromagnetic interference (EMI) from disrupting processing logic
Mitigating electrical noise in controller power supplies prevents high-frequency electromagnetic interference on incoming lines from disrupting the internal processor. Industrial plants contain significant noise sources, such as heavy motors and switching relays, which can cause memory corruption or logic execution faults. Power line filtering and isolation ensure reliable operations by supplying clean, stable DC power.

59. (B) An output that energizes when rung conditions are met
A coil in a ladder logic program represents an output element situated on the far right of a rung. When the preceding input contacts provide logic continuity across the rung, the coil is energized, updating its associated memory address. This state is then written to physical output channels, driving devices like solenoid valves or motor contactors.

60. (B) CTD increments its value on a true-to-false transition.
A count-down instruction decreases its accumulated value when the preceding rung transitions from false to true. It does not respond to true-to-false transitions. This false-to-true transition detection ensures accurate count adjustments for every input pulse. In contrast, count-up instructions increment on similar transitions, and both require dedicated reset instructions to clear accumulated values.

61. (A) Octal omits digits 8 and 9, unlike standard decimal systems.
Octal memory addressing formats utilize a base-eight number system, omitting the digits eight and nine. Historically, older systems mapped I/O channels to groups of eight, matching this base-eight format. Modern controllers have transitioned to standard decimal and tag-based formats, simplifying system development by removing the constraints of base-eight numbering during configuration.

62. (C) It minimizes CPU scan time and program overhead.
Executing a dedicated division instruction inside a controller requires significantly less scan time than running a software loop of repeated subtractions. The division instruction runs as a single compiled hardware operation within the ALU, minimizing CPU overhead. This optimized execution helps prevent scan time inflation, ensuring responsive execution of other time-critical safety logic.

63. (D) Rungs between the JMP and LBL instructions are skipped.
When an active jump instruction is processed, the controller immediately shifts execution to the specified target label, skipping all intermediate rungs. The outputs within the bypassed section remain in their last evaluated states rather than updating during the scan. This feature allows conditional execution of program sections, improving cycle speeds when certain functions are inactive.

64. (D) Both A and R are true and R is the correct explanation of A.
Shift registers excel at tracking items on conveyor systems because they move binary data through an array with each physical input pulse. When a sensor detects a part, a bit is loaded, and it shifts forward with each pulse from a conveyor encoder. This direct relationship shows how bit-shifting logic implements spatial tracking in industrial material handling systems.

Click Here to Buy book on Amazon

9. (D) Ladder logic allows logical contacts to be reused infinitely in the software.
Unlike traditional physical relays that are constrained by their hardwired contacts, programmable logic controller ladder logic operates in a software-defined environment. A single discrete input channel or internal memory bit can be referenced as virtual normally open or normally closed contacts infinitely throughout the software. This software reuse simplifies complex logic design and reduces physical control cabinet hardware requirements.

10. (A) RTO maintains its accumulated value when the rung condition goes false.
A retentive timer preserves its accumulated elapsed time when the preceding rung logic transitions from true to false. In contrast, standard non-retentive timer instructions automatically reset their accumulators to zero as soon as their enable rung loses logical continuity. Retentive timers require a dedicated software reset instruction to clear the accumulated value back to zero.

11. (B) It maps individual bits within larger memory registers.
Word-based memory mapping formats represent discrete input and output channels by assigning each sensor state to a specific bit within a larger memory register. These registers are structured as sixteen-bit or thirty-two-bit words. The controller can address and manipulate individual bits within these larger words to monitor binary inputs or drive individual digital output contacts.

12. (B) LES
To evaluate if a process variable is strictly below a specific limit, programmable logic controllers utilize the less-than comparison instruction. This logical block compares two source values, usually representing the dynamic sensor reading and a constant threshold. The instruction transitions to a true logic state only when the first source is mathematically smaller than the second source value.

13. (A) It de-energizes a specific zone of outputs simultaneously.
The master control relay instruction provides structural zone control over specified segments of user code, allowing the program to de-energize multiple outputs simultaneously. When the master rung conditions evaluate to false, all non-retentive outputs within the bounded master control relay zone are systematically turned off. This logical function enhances software safety coordination and simplifies sequential process shutdowns.

14. (B) Both A and R are true and R is the correct explanation of A.
Using a bitwise logic operation allows specific portions of a register word to be isolated while filtering out unwanted bits. The truth table for this logical operation dictates that any bit combined with a zero evaluates to zero, while a bit combined with a one retains its original state. Consequently, the operational behavior directly explains why this masking technique works.

15. (D) SQX
Standard industrial controllers support specific sequencer commands such as sequencer output, sequencer compare, and sequencer load to automate complex step-by-step processes. These instructions reference pre-defined data arrays to sequence mechanical actions, check system feedback, or write operational parameters. The instruction designated with an X does not exist in standard industrial ladder programming environments.

16. (C) Apply a linear scaling instruction using the slope-intercept formula.
Industrial controllers handle linear analog loops by converting physical currents into engineering units through scaling algorithms. Applying the slope-intercept formula allows the software to map the incoming digital count representation of a four-to-twenty milliampere range into the target temperature range. This mathematical transformation accounts for both the gain scale factor and the zero offset value accurately.

17. (B) Steady-state error
The integral action within a closed-loop controller accumulates the system error over time, continuously adjusting the control output to drive the offset to zero. While proportional control can leave a persistent steady-state offset, the integrated sum of errors forces the output to correct for this offset. This continuous correction completely eliminates steady-state errors under constant operating conditions.

NODIA

sensors and actuators in remote locations. It monitors input signals, stores local data, and transmits telemetry packets back to the central master station over long-distance links. This unit provides remote monitoring and control for distributed systems, including gas wells and electrical substations.

75. (C) P-4, Q-2, R-1, S-3
CAN networks utilize four distinct frame types, each serving a specific communication function:
P. Data frames carry actual payload information across the bus.
Q. Remote frames request data from other nodes.
R. Error frames are transmitted immediately by any node detecting a bus error.
S. Overload frames provide a delay between the current and next frames.

76. (B) Inputs are in the same state.
An exclusive-NOR gate is a digital comparator that outputs a logic-high signal when all of its input channels are in the same state. If the inputs are either both low or both high, the output evaluates to true. Conversely, if the inputs differ, the output remains low, which is the exact inverse of the standard XOR gate.

77. (A) Directly proportional, based on machine cycles.
The rate at which a microcontroller executes instructions is directly proportional to its clock frequency, as determined by internal machine cycles. Each instruction requires a fixed number of clock ticks, or machine cycles, to complete the fetch-decode-execute process. Therefore, increasing the master oscillator frequency directly reduces instruction execution time, enabling faster real-time control actions.

78. (C) Execution of a Jump or Branch.
The program counter registers the memory address of the next instruction to be executed by the processor. Normally, it increments sequentially to execute consecutive program lines. However, when the processor executes a jump, branch, or subroutine call instruction, the counter is loaded with a non-sequential target address. This jump diverts execution to another part of the program.

79. (D) It is completely independent of the specific underlying processor architecture.
Assembly language is a low-level programming language that is closely tied to the specific hardware architecture of a processor. Each assembly instruction translates directly into a unique machine code instruction for a given processor family. Consequently, assembly code written for one microcontroller architecture cannot run on a different architecture without being completely rewritten.

80. (C) Measure external pulse widths.
In capture mode, a microcontroller timer records the current timer value into a register when a transition occurs on an input pin. This hardware-driven capture prevents software delays from affecting measurement accuracy. This mode is used to measure pulse widths, signal periods, and frequencies from sensors like tachometers and flow meters.

81. (C) I and III
The arithmetic logic unit executes math and logic operations within the processor but does not store programs, which are kept in non-volatile flash memory. Additionally, many modern controllers still use battery-backed RAM or non-volatile RAM to preserve retentive variables during power outages. Therefore, claiming the ALU handles hard drive storage or that battery-backed RAM is obsolete is incorrect.

82. (D) Analog-to-Digital conversion
Discrete I/O modules in programmable logic controllers process binary signals, providing electrical isolation, signal conversion, and LED status indications. However, they do not perform analog-to-digital conversions, which require specialized analog input cards with onboard ADCs. These cards convert continuous analog signals, such as voltage or current, into digital registers for the CPU.

83. (A) Using shielded twisted-pair cables and proper grounding
Using shielded twisted-pair cabling combined with proper single-point grounding is the standard method to mitigate electromagnetic noise in industrial signal lines. The twisted-pair geometry cancels differential electromagnetic fields, while the metallic shield blocks high-frequency electrostatic noise. These practices ensure reliable analog measurements and

Downloaded from www.pdf.tube

does not handle analog-to-digital conversions, which require separate ADC circuitry. It also does not store C program logic, which is kept in non-volatile flash memory registers.

104. (C) Assembly
Assembly language is a low-level programming language that maps directly to the instruction set architecture of a specific microcontroller. Because it uses mnemonic codes to represent underlying binary machine instructions, it provides programmers with direct control over hardware registers and memory. This direct hardware link makes assembly highly architecture-specific, unlike high-level portable programming languages.

105. (D) System safety peripheral
The watchdog timer is a safety peripheral designed to reset the microcontroller if software execution hangs or enters an infinite loop. This independent timer counts down continuously, and the program must periodically write to reset its count. If the software crashes and fails to clear the timer, the watchdog forces a hardware reset, restoring reliable operations.

106. (A) A watchdog fault occurs, halting the PLC to ensure safety.
If a programmable controller scan cycle time exceeds the preset watchdog threshold, the processor triggers a fatal watchdog fault and halts immediately. This safety shutdown ensures that the controller does not get stuck in an execution loop, preventing unpredictable control outputs. Halting the CPU de-energizes all outputs, placing the industrial machinery into a safe state.

107. (B) The need to measure continuously variable physical quantities.
Analog input modules are designed to measure continuously variable physical quantities, such as temperature, pressure, flow, and level, which have infinite intermediate values. These modules convert variable electrical signals, like voltage or current loops, into digital registers. In contrast, discrete modules can only detect binary states, making them unsuitable for monitoring varying process variables.

108. (B) Provides a path to ground (common) for the connected circuit.
A sinking input or output module provides a direct path to the electrical ground common for its connected circuit. When activated, current flows from the positive source of the external device, through the circuit, and into the sinking terminal to ground. Sinking components must be paired with sourcing devices to establish a complete electrical loop.

109. (A) Normally Closed Contact - Passes logic when energized
A normally closed contact is designed to pass logic or current when its controlling coil is de-energized. When the coil is energized, these contacts open, breaking logic continuity. Therefore, stating that a normally closed contact passes logic when energized is incorrect regarding standard relay operations. Other pairings, such as coils representing outputs, are correct.

NODIA

110. (C) TON - Timer On Delay: Starts timing when rung condition goes true
The timer-on delay is a standard instruction that begins counting elapsed time as soon as its enabling rung condition becomes true. If the rung remains true until the accumulated time matches the preset value, the done bit is set. Non-retentive timer instructions will reset their accumulator values if the enabling rung becomes false.

111. (D) Tags improve program readability and simplify memory management.
Tag-based programming in modern controllers improves code readability and simplifies memory management by using descriptive text names instead of absolute addresses. Rather than tracking register numbers like N7:0, programmers can define descriptive tags like tank-temperature. This approach allows software development to proceed independently of physical memory layouts, making programs easier to modify.

112. (C) Source A is less than or equal to Source B
The less-than-or-equal-to comparison instruction in a programmable controller evaluates to a true logic state when the first source value is less than or equal to the second source value. While the standard less-than instruction requires the first value to be strictly smaller, this instruction remains true if both compared register values are mathematically equal.

overlap corrupts both data packets, requiring the nodes to back off and retransmit.

94. (A) It is less susceptible to voltage drops over long cable runs.
A four-to-twenty milliampere current loop is highly resistant to voltage drops over long cable runs compared to voltage-based signals. Because the transmitter regulates loop current, the signal remains constant regardless of wire resistance and cable length. This stability makes current loops ideal for long-distance industrial monitoring where voltage drop would cause measurement errors.

95. (D) It superimposes digital FSK signals on top of the 4-20 mA analog loop.
The HART protocol superimposes digital FSK communication signals on top of standard four-to-twenty milliampere analog current loops. This frequency-modulation technique uses high-frequency tones to represent binary values without affecting the average analog signal. This hybrid design allows simultaneous transmission of primary analog process variables and advanced digital diagnostic or configuration data.

96. (C) Distributed digital control over a shared bus.
Fieldbus networks connect multiple intelligent instruments to a shared physical cable using a distributed digital control model. This network architecture allows bidirectional communications, enabling devices to share process measurements, control variables, and configuration diagnostics. This shared bus structure simplifies system wiring, replaces legacy analog wiring, and supports advanced distributed control algorithms.

97. (A) II, I, III
In CAN network arbitration, lower numeric identifier values receive higher transmission priority. If base identifiers match, standard eleven-bit frames take precedence over extended twenty-nine-bit frames because the Standard Identifier Extension bit is driven dominant in standard frames. Therefore, the standard frame with identifier five has priority, followed by the extended frame, and finally the larger identifier.

98. (D) SCADA
Supervisory control and data acquisition systems use long-distance telemetry networks to monitor and manage remote municipal pumping stations. This technology transmits field sensor measurements and equipment status from remote RTUs back to a central control room. This centralized monitoring allows operators to manage wide-area infrastructure, reducing the need for local operations staff.

99. (A) Motor contactor overload relay
SCADA software systems include alarm management blocks, historical databases, and graphical human-machine interfaces to coordinate operations. However, a motor contactor overload relay is a physical hardware safety device installed inside a motor control center panel. This electrical hardware protects motors from thermal overloads and does not run as a software module in supervisory control structures.

100. (C) It issues commands to RTUs and aggregates supervisory data.
The master terminal unit serves as the central host controller in SCADA networks, issuing commands and aggregating data from remote field stations. This central server polls remote terminal units, processes incoming telemetry, updates historical databases, and drives supervisory screens. It acts as the primary communication hub coordinating remote process control across wide-area networks.

101. (A) The output is true if all inputs are true.
The logical AND function is a fundamental boolean gate that outputs a true state only when all of its input channels are true. If any input channel transitions to a false logic level, the resulting output evaluates to false. This logical function is represented in ladder programming as a series configuration of open contact blocks.

102. (D) Von Neumann
Von Neumann processor design utilizes a single unified data bus to fetch both executable program instructions and operational data from a shared memory space. This shared layout prevents the CPU from reading an instruction and accessing data registers at the same time. This structural limitation is known as the Von Neumann bottleneck in computer architectures.

103. (B) I, II and IV
The arithmetic logic unit executes mathematical operations and bitwise logical calculations inside the processor, interacting directly with core working registers. However, this hardware block

Click Here to Buy book on Flipkart

digital communications in high-interference environments.

84. (C) Graphical Language
According to the IEC standard, ladder logic is classified as a graphical programming language. It uses visual symbols, such as contacts, coils, and functional blocks, arranged along vertical rails to represent control circuits. This graphical layout is designed to mimic traditional electrical schematic diagrams, making it accessible to maintenance technicians and engineers.

85. (A) It reaches zero when depleted, simplifying stop logic.
Using a count-down instruction in a batching process simplifies stop logic by tracking when the count reaches zero. The controller loads a target batch count into the register and decrements it with each pulse. When the count reaches zero, the done bit toggles, triggering output blocks to stop material feed and proceed to the next step.

86. (B) II, I, IV, III
The sequential operation of a programmable controller scan cycle begins by reading physical inputs and updating the input image table. Second, the CPU executes the user program logic from top to bottom. Third, the processor writes the calculated states to the output image table. Finally, the controller performs internal diagnostics and handles network communications.

87. (B) A division-by-zero math fault occurs, potentially halting execution.
If a controller executes a division instruction with a register value of zero, a division-by-zero math fault occurs. In industrial automation, dividing by zero is an invalid mathematical operation that triggers a CPU fault. This fault can halt the processor immediately to prevent unpredictable control outputs, unless the error is caught by fault-handling logic.

88. (C) Subroutines modularize code and reduce memory usage.
Subroutines allow engineers to modularize large programs, organizing code into logical segments that run only when called. This structure reduces overall memory usage by reusing common functions, avoiding the need to duplicate identical rungs across multiple program files. This approach simplifies troubleshooting, clarifies program logic, and optimizes processor execution speeds.

89. (D) Tracking products moving along automated conveyors.
A bitwise shift register is used to track parts moving along automated assembly lines. When a sensor detects a part, a tracking bit is loaded into the array. As physical conveyor pulses trigger the instruction, the bit moves through the register, tracking the part's physical location for downstream actions like sorting.

90. (A) SQC
The sequencer compare instruction is designed to evaluate input data against reference values at each step of a process. This instruction reads data registers and compares them to a reference file, using a mask to ignore unused bits. If the comparison matches, the instruction sets an output status bit, allowing the sequence to advance.

91. (B) The smallest change the ADC can convert and represent.
The resolution of an analog input module defines the smallest change in the input signal that the ADC can resolve. This measurement capability is determined by the bit depth of the converter. Higher bit depths partition the analog voltage or current range into more steps, allowing the processor to detect smaller variations in real-world process variables.

92. (D) I, II and IV
Proportional control adjusts output based on the current error, while derivative action responds to the rate of error change, making it sensitive to high-frequency noise. Loop tuning balances these parameters to optimize system response without excessive oscillation. In contrast, integral control addresses historical accumulated error rather than predicting future errors, which is handled by derivative action.

93. (A) Multiple nodes transmitting on a shared medium simultaneously.
Packet collisions in industrial networks using CSMA/CD occur when multiple nodes transmit data on a shared physical medium at the same time. Since nodes listen to the bus before transmitting, two nodes may determine the line is clear and start transmitting simultaneously. This

NODIA

113. (B) The MCR dictates whether outputs within its zone can be energized.
The master control relay instruction establishes a zone of control, dictating whether the outputs within its boundaries can be energized. When the master rung conditions are true, the rungs within the zone are evaluated normally. If the master rung is false, the controller bypasses normal output evaluation, de-energizing all non-retentive outputs inside that zone.

114. (C) Both A and R are false.
Executing a move instruction in a controller copies data from a source address to a destination register without altering the original source data. Furthermore, data manipulation instructions do not clear source memory locations, and there is no risk of memory overflow from leaving source data intact. Therefore, both the assertion and its reasoning are incorrect.

115. (A) The sequence may advance across multiple steps in a single scan.
Programming multiple continuous sequencer steps without transition logic can cause the sequence to skip ahead across several steps in a single scan. Without transition delays, the controller evaluates and satisfies subsequent step conditions instantly, executing multiple steps during one scan cycle. This uncontrolled stepping can cause unexpected machine movements, presenting safety hazards to equipment and operators.

116. (C) Proportional analog voltage or current signals
Digital-to-analog converters in controller output modules convert internal numeric data registers into proportional analog voltage or current signals. These standard electrical outputs, typically zero-to-ten volts or four-to-twenty milliamperes, are used to drive analog field devices. Examples of connected equipment include modulating control valves, speed references for variable frequency drives, and analog chart recorders.

117. (A) It provides output proportional to the error rate of change.
Derivative action in a closed-loop controller determines its control output based on the rate of change of the process error. This mathematical calculation acts as a predictive control element, dampening system responses to prevent overshoot when errors change rapidly. This rate-of-change response helps stabilize the control loop, especially in fast-responding process environments.

118. (D) Ring topology
A ring network topology connects each device sequentially to two other devices, forming a continuous closed loop for communication traffic. Data packets travel around this closed loop in a single direction, with each node acting as a repeater to boost the signal. This structure often incorporates redundant pathways, allowing communication to continue if a cable breaks.

119. (B) Frequency Shift Keying (FSK)
The digital communication standard within the HART protocol relies on frequency shift keying modulation to transmit data over existing current loops. This method superimposes two distinct high-frequency tones representing logical one and zero states onto the four-to-twenty milliampere current signal. Because the average value of these high-frequency sine waves is zero, digital data does not interfere with analog measurements.

120. (C) Devices share the loop and communicate digitally using fixed current.
In HART multidrop configurations, several field instruments are connected in parallel along a single wire loop. Because multiple devices share the same loop, individual analog current changes would corrupt measurements. To prevent this interference, the analog current of each device is locked at a constant four milliamperes, and all process variables are transmitted through digital FSK data packets.

121. (D) Publisher-Subscriber
To support time-critical data transfer without the delays of master-slave polling, Foundation Fieldbus networks utilize a publisher-subscriber model. In this architecture, a device publishes its updated process variable onto the bus at scheduled intervals. All other devices that require this data subscribe to the channel, reading the packet directly off the bus without a master request.

122. (A) A physical bus fault has occurred.
If a controller area network node transmits a dominant bit but reads back a recessive bit, a physical bus fault has occurred. The physical layer of CAN bus ensures that a dominant bit

NODIA

downward to evaluate the subsequent rung from top to bottom.

160. (D) I, II, III, IV
The operation of a standard timer on-delay instruction follows a precise linear sequence. First, the preceding rung logic conditions must evaluate as true. Once enabled, the timer accumulates elapsed time during each scan. When this accumulated value eventually equals the preset target, the instruction energizes the done bit, signaling that the timed period has finished.

161. (B) Bit-level addressing
Discrete inputs and outputs in a programmable logic controller are binary in nature, representing either an on or off state. To manage these signals efficiently, the processor utilizes bit-level addressing. This memory mapping method allocates a single bit within a data register to represent and manipulate the physical state of each specific physical connection point.

162. (D) The values of Source A and Source B are mathematically equal.
The equal instruction in programmable logic controllers is a comparison block that monitors two distinct data parameters. During each execution scan, the processor compares the value stored in the first source with the value in the second source. If both values are mathematically identical, the instruction evaluates as true, allowing logical continuity to pass downstream.

163. (A) When the MCR rung is false, non-retentive outputs inside the MCR zone are de-energized.
The master control relay instruction is a program control mechanism used to establish logical zones. When the primary rung controlling the master control relay evaluates as false, the processor automatically de-energizes all non-retentive outputs located within that designated zone. This override occurs without executing individual rungs, allowing the system to safely shut down sections of logic.

164. (D) Both A and R are true and R is the correct explanation of A.
Shift registers are valuable tracking tools in industrial automation. In a conveyor system, physical sensors detect product status and write corresponding binary values into the start of a register. As the conveyor moves, the controller shifts these bits sequentially through the array, precisely mirroring the physical movement of products and enabling the tracking of defects.

165. (A) Sequencers simplify the programming and troubleshooting of multi-step machine cycles.
Sequencer instructions provide significant structural benefits compared to using multiple cascaded timers for complex operations. By storing output states within a structured data array and indexing through them, sequencers greatly simplify the development and maintenance of multi-step machine cycles. This structured approach reduces overall program complexity, making physical troubleshooting far more straightforward for maintenance personnel.

166. (D) It converts discrete binary values in the PLC memory into continuous voltage or current output signals.
Digital-to-analog conversion in programmable logic controllers enables the system to interact with analog field equipment. The conversion card reads discrete binary numerical values stored within the controller's processor memory and translates them into continuous, proportional voltage or current signals. This allows the system to modulate devices such as variable frequency drives and control valves.

167. (B) Error
In closed-loop feedback systems governed by proportional-integral-derivative algorithms, the term error represents a fundamental control parameter. It is mathematically defined as the direct difference between the desired target point, known as the setpoint, and the actual monitored state, known as the process variable. The controller calculates this value to determine the appropriate output correction.

168. (C) Reduced cabling requirements and enhanced diagnostic capabilities.
Implementing industrial field networks, such as Profinet or DeviceNet, offers major benefits over traditional point-to-point hardwiring. By utilizing a single shared communication cable rather than individual copper runs for every device, installation complexity and cabling weight are reduced. Furthermore, these networks enable advanced diagnostics, providing detailed real-time status updates directly from smart devices.

Downloaded from www.pdf.tube

limited or that the scan cycle is for SCADA is incorrect.

132. (C) Optical isolation
Optical isolation is widely used in discrete controller I/O modules to protect sensitive microprocessor circuitry from external voltage transients. This isolation uses light-emitting diodes and phototransistors to transmit signals across an electrical gap. This gap blocks high-voltage spikes, ground loops, and electrical noise from entering the backplane, ensuring stable system operations.

133. (A) Higher efficiency and smaller size, but with more electrical noise.
Switch-mode power supplies provide higher conversion efficiency and smaller physical footprints than traditional linear power supplies. By switching transistors at high frequencies, these supplies minimize thermal loss and reduce transformer size. However, this high-frequency switching introduces electrical noise on output lines, requiring internal filtering to protect the controller logic from interference.

134. (D) It energizes only when all three contacts are closed.
A series configuration of three normally open contacts on a ladder rung represents a logical AND gate, requiring all contacts to close to energize the output. If any contact in the series path remains open, logic continuity is broken and the output remains off. This configuration is standard for interlocking safety conditions in industrial processes.

135. (B) When the accumulated value equals the preset value, the done bit is set.
In a timer-on-delay instruction, the accumulated value increments as long as the enabling rung remains true. When the accumulated value equals the preset value, the timer completes its cycle and sets its done bit. This status bit is then used by downstream logic to trigger delayed sequence actions in the control program.

136. (C) It allows the addressing and manipulation of individual binary states.
Bit level memory addressing in programmable logic controllers enables the direct control of single bits within the memory map. This type of addressing is highly efficient for discrete inputs and outputs, representing basic binary states such as on or off. It eliminates the need to process entire data words when only a single binary status requires evaluation.

137. (D) The sum exceeds the maximum limit of the destination data type.
During the execution of an addition instruction in a programmable logic controller, the processor tracks mathematical boundaries. If the calculated sum of the inputs exceeds the maximum value capacity of the specified destination register, an arithmetic overflow occurs. This boundary violation triggers the system to set the overflow error flag to notify the operating program.

138. (A) Program Flow Control
The Skip instruction is a control mechanism utilized to alter the sequential execution of a programmable logic controller program. By bypassing specific rungs or segments of code under designated conditions, this instruction manages how the processor navigates through program memory. Consequently, it is categorized under program flow control operations rather than data manipulation or arithmetic.

139. (B) Logical AND with 0xF0
Eliminating the lower four bits of an eight bit register requires a bitwise logical operation that selectively clears specific bits while preserving others. Performing a logical AND operation with the hexadecimal mask zero X F zero accomplishes this task. The upper nibble remains unchanged because it is paired with ones, whereas the lower nibble is forced to zero.

140. (B) Manipulating or comparing multi-word data arrays concurrently.
In advanced programmable logic controller programming, matrix operations refer to mathematical or logical manipulations performed on entire arrays of data. Instead of evaluating individual registers sequentially, a matrix instruction allows the processor to compare, transfer, or modify multiple data words simultaneously. This approach optimizes execution speed and simplifies complex logic sequences involving large datasets.

NODIA

141. (A) Sampling analog inputs to assign binary values.
Analog to digital converters function by measuring continuous physical voltage or current signals at specific intervals. This

must overwrite a recessive state. Reading back a recessive state indicates a hardware problem, such as a short to power or open termination resistor.

123. (B) Thermocouple with a signal conditioner
To interface high temperatures with a computer-based acquisition system, a thermocouple paired with a signal conditioner is the standard solution. The thermocouple sensor produces a small, non-linear millivolt output proportional to temperature differences. The signal conditioner amplifies this microvolt signal, filters out electrical noise, and linearizes it into a standard voltage for the A/D converter.

124. (B) Local operator interface
An HMI panel installed next to a machine on a factory floor acts as a local operator interface. This terminal displays real-time process data from the controller, allowing operators to monitor operations, adjust setpoints, and view local alarms. This local interface is dedicated to a specific machine, unlike central supervisory systems that oversee entire plants.

125. (A) P-2, Q-4, R-3, S-1
A remote terminal unit incorporates several components serving distinct roles:
- P. The CPU executes control logic and processes local data.
- Q. The communication interface transmits telemetry packets to the central MTU.
- R. The input-output modules connect directly to field instruments.
- S. The power supply converts incoming AC mains into low-voltage DC operating power.

126. (C) PLCs significantly reduce the required control panel footprint.
Programmable logic controllers reduce the required physical space in control enclosures by replacing hundreds of bulky electromagnetic relays with solid-state software logic. Instead of installing extensive rows of relays, timers, counters, and terminal blocks, engineers can implement these functions in software. This optimization decreases control panel footprints, lowers cabinet costs, and simplifies wiring layouts.

127. (D) Physically separate memory buses for data and code
Von Neumann processor design features a single shared memory space and a common bus structure for both instructions and data. It does not use physically separate buses, which is a key characteristic of Harvard architectures. This shared-bus design simplifies circuit layouts but prevents simultaneous code and data fetches, leading to the Von Neumann bottleneck.

128. (C) Hold temporary data for ALU access.
Microcontroller general-purpose registers hold temporary operand values and intermediate calculation results for rapid access by the arithmetic logic unit. These registers are located inside the CPU core, providing faster access times than the main SRAM data bus. This register-based architecture ensures efficient execution of mathematical operations, logical modifications, and dynamic data transfers during program execution.

129. (B) A low-level language using mnemonics.
Assembly language is a low-level programming language that represents binary machine instructions using human-readable mnemonics. It provides programmers with direct access to hardware resources, such as processor registers, accumulator structures, and memory locations. This language is highly specific to a processor family, requiring an assembler to translate the mnemonic code into executable binary files.

130. (D) Halting the main program execution temporarily to handle a specific event.
An interrupt service routine is a specialized block of code that executes when a specific hardware or software event occurs. When triggered, the CPU temporarily suspends the main program, saves the current execution context on the stack, and runs the handler routine. Once the ISR completes, the processor restores the context and resumes the main program.

131. (D) II and III
The scan cycle is a foundational execution mechanism in programmable logic controllers, not SCADA master terminal units. Additionally, controller memory capacity is not limited to one megabyte, with modern CPUs offering many megabytes of storage for programs, diagnostics, and variables. Therefore, stating that memory is

Click Here to Buy book on Amazon

from multiple locations. Conversely, the remote terminal unit is deployed in harsh, distributed environments near the physical equipment. It interfaces directly with field sensors and actuators, converting physical signals into digital telemetry.

151. (B) Multiplication
In mathematical logic, Boolean AND operations behave identically to binary multiplication. The output of an AND gate is high only when all inputs are high, mirroring how a multiplication product is non-zero only when all factors are non-zero. Conversely, Boolean OR operations are more conceptually analogous to mathematical addition, where any high input yields a high output.

152. (C) Central Processing Unit (CPU)
The arithmetic logic unit is a core internal component of the central processing unit in a microcontroller. It is responsible for executing all mathematical computations, such as addition and subtraction, alongside logical evaluations like bitwise AND, OR, and NOT. Other microcontroller segments, including non-volatile storage and clock circuits, support this primary processing engine.

153. (C) I, III and V
In microcontroller architectures, several key characteristics define processing operation. Flash memory is inherently non-volatile, retaining programmed code when power is disconnected. External interrupts require software routines, specifically interrupt service routines, to process events. Additionally, Harvard architecture is distinguished by utilizing separate, independent buses for instructions and data rather than a single unified bus.

154. (D) Hard-disk sector addressing
Central processing units in microcontrollers utilize specific addressing modes to retrieve operands from internal registers or memory locations. Standard modes include immediate, register direct, and register indirect addressing. Hard-disk sector addressing is not used in microcontrollers, as these embedded devices rely on solid-state flash or static random-access memory rather than mechanical magnetic disk storage.

155. (B) The port pins are configured as inputs, typically in a high-impedance state.
When a microcontroller's data direction register is configured with all zeros, the corresponding physical I/O pins are set to function as inputs. In this state, the pins exhibit high impedance, meaning they draw negligible current from the connected external circuits. This high-impedance configuration allows the microcontroller to safely read external voltage levels.

156. (B) Non-volatile memory, such as Flash or EEPROM, retains the user program during power loss.
Program retention in programmable logic controllers depends on non-volatile memory types such as Flash or electrically erasable programmable read-only memory. Unlike volatile random-access memory, which requires continuous battery power to prevent data loss, non-volatile storage securely preserves the compiled user application program and configuration settings during complete electrical power interruptions.

157. (A) A sourcing field device.
Electrical current flow in direct current industrial circuits requires matching compatibility between modules. A sinking input card on a programmable logic controller provides a path to the common electrical ground. To complete the circuit and allow current to flow properly, this input module must be connected to a sourcing field device that actively provides positive voltage.

NODIA

158. (C) Optocoupler
Optical isolation in programmable logic controller input and output circuits is achieved through the use of an optocoupler. This semiconductor component contains an internal light-emitting diode paired with a photosensitive transistor. By transmitting signals across a physical gap using light, it prevents dangerous high-voltage transients from crossing over and damaging the sensitive central processing unit.

159. (D) Left to right, top to bottom.
The execution cycle of ladder logic programs follows a highly structured, sequential path. The processor reads each individual rung from left to right to evaluate the logical conditions of the input instructions. Once a rung is processed and its outputs are updated, the controller moves

measurement process, known as sampling, translates the infinitely variable analog inputs into discrete binary numerical representations that a digital processor can interpret. This conversion is fundamental for microcontrollers and programmable logic controllers to process environmental data.

142. (A) I, III and IV
Programmable logic controllers are fully capable of executing proportional integral derivative loops. The associated tuning parameters are stored within dedicated data blocks to maintain system configuration. During operation, the control instruction reads the process variable from an analog input module and calculates the resulting manipulated variable output to regulate the process loop dynamically.

143. (D) A single trunk line break can disrupt communication to downstream devices.
A simple bus topology connects all network nodes to a single central trunk cable. A primary disadvantage of this physical layout is its lack of redundancy. A single physical break anywhere along the primary trunk line immediately interrupts the signal path, completely disabling communication to all downstream devices located past the point of the physical rupture.

144. (B) 4 mA
In industrial instrumentation, the four to twenty milliampere current loop is a standard analog signaling method. Within this range, a current value of four milliamperes is designated to represent the lowest limit of the calibrated measurement scale. This live zero configuration allows the system to easily distinguish between a true zero reading and a broken wire.

145. (B) An instrument supporting simultaneous analog and digital communication.
Highway Addressable Remote Transducer field devices support simultaneous analog and digital communication over a standard current loop. By superimposing a high frequency digital signal onto the traditional four to twenty milliampere analog current, these smart instruments transmit process variables alongside critical diagnostics, calibration parameters, and device status information without requiring additional dedicated field wiring.

146. (D) The physical or logical layout of the network stations and links.
Network topology in industrial Fieldbus systems describes the structured arrangement of the physical or logical links and nodes. This configuration defines how different control stations, sensors, and actuators are interconnected. Choosing the correct topology, such as star, ring, or bus, directly influences system diagnostic capabilities, overall cabling requirements, and physical network fault tolerance.

147. (A) Dominant bits (0) overriding recessive bits (1) on the physical medium.
Non destructive bitwise arbitration in Controller Area Network systems relies on the electrical characteristics of the physical bus. Nodes monitor the bus while transmitting, where dominant zero bits physically override recessive one bits. If a node detects a dominant bit while transmitting a recessive bit, it ceases transmission immediately, allowing higher priority messages to pass without collision.

148. (C) Signal Conditioner - Amplifies, filters, or isolates raw sensor signals.
In data acquisition systems, physical sensors often generate low voltage signals that are highly vulnerable to electrical noise. A signal conditioner performs the vital function of isolating, amplifying, and filtering these raw inputs. This preparation ensures the signals are converted into stable, standardized voltage or current ranges compatible with analog to digital converters and microcontrollers.

149. (A) It enables historical trending, long-term archiving, and business analytics.
Integrating supervisory control and data acquisition software with an enterprise relational database enhances system utility. This connection facilitates the continuous storage of high volume industrial process data over extended periods. By establishing a centralized repository, organizations can generate comprehensive historical trends, archive operational logs, and perform advanced business analytics to optimize overall productivity.

150. (C) P-1, Q-2, R-1, S-2
In supervisory systems, the master terminal unit serves as the primary central controller, initiating periodic polling requests to gather data

Downloaded from www.pdf.tube

169. (D) Highway Addressable Remote Transducer
The acronym HART stands for Highway Addressable Remote Transducer. It is a highly robust industrial communication standard that allows smart transmitters and actuators to transmit digital data. By superimposing low-level digital signals on top of standard four-to-twenty milliampere analog wiring, it provides secondary information such as device diagnostics and configuration without interrupting the primary analog measurement.

170. (A) Supported and implemented by all HART-compliant field devices.
Within the structural framework of the Highway Addressable Remote Transducer protocol, commands are categorized into specific levels. Universal commands represent the most basic instructional tier and must be fully supported and implemented by every single HART-compliant field instrument. These standardized commands allow any master host to read essential data, including the primary variable and device description.

171. (A) A standardized layered framework for network protocol design.
The Open Systems Interconnection model defines a structured seven-layer framework for network protocol design and communication. Often referenced in Fieldbus engineering standards, this model compartmentalizes different communication functions, from the physical hardware connections up to the user-level application software. This modular approach ensures interoperability between different industrial networking devices and protocols.

172. (B) They are used to match transmission line impedance and prevent signal reflections.
Installing a one-hundred-and-twenty-ohm terminating resistor at each physical end of a Controller Area Network bus is crucial for signal integrity. These components are selected to match the characteristic impedance of the transmission line cabling. By absorbing electrical energy at the physical boundaries of the bus, they prevent signal reflections that would otherwise corrupt digital packets.

NODIA

173. (A) Increased susceptibility to operating system updates, software instability, and IT security threats.
Implementing complex computer-based control software introduces specific operational vulnerabilities compared to standalone programmable logic controllers. These systems are highly susceptible to background operating system updates, software instability, and driver conflicts. Additionally, connecting these environments to standard computer networks exposes the control layer to sophisticated information technology security threats and unauthorized access.

174. (C) Supervisory level control and data acquisition
Supervisory control and data acquisition systems operate at a high administrative level within the industrial automation hierarchy. Rather than performing local high speed deterministic closed loop physical control, these platforms monitor widely distributed industrial processes, collect real time operational data, and present a graphical interface for human operators to issue high level control commands.

175. (B) P-1, Q-2, R-3, S-4
Industrial programming instructions are classified into distinct functional categories to execute specific tasks. Addition is grouped under arithmetic calculations, while the move instruction manages standard data transfer between memory registers. The jump instruction handles program flow control by bypassing rungs, and bitwise AND operates as a logical instruction manipulating individual binary states.

176. (C) The output signal is inverted to a low (0) state.
In digital logic circuits, a Boolean NOT gate operates as a fundamental signal inverter. When a high, or binary one, input signal is applied to this logical gate, the internal circuitry inverts the voltage level. This logical inversion directly forces the resulting output signal into a low, or binary zero, state.

177. (B) Access instructions and data concurrently using separate memory buses.
Microcontrollers designed with Harvard architecture utilize physically separate memory blocks and dedicated buses for program instructions and data storage. This hardware separation allows the central processing unit

215. (B) SQC (Sequencer Compare)
To verify if a multi-step machine sequence aligns with a predetermined diagnostic pattern, the sequencer compare instruction is the most appropriate selection. It is designed to compare physical input data against a defined array of diagnostic reference words, checking for exact status matches during designated steps of the operational cycle.

216. (C) Raw digital converter counts into physical engineering units.
Analog signal scaling is a mathematical conversion process within a programmable logic controller. It translates raw digital data, generated as binary counts by an analog-to-digital converter, into meaningful engineering units such as temperature, pressure, or flow. This scaling ensures operators and control algorithms interpret inputs in standard physical values.

217. (D) The percentage of input error required to produce a full-scale change in the output.
In proportional integral derivative control, the proportional band is defined as the percentage of error input required to produce a full scale change in the controller output. A narrower proportional band results in a highly aggressive controller response, whereas a wider band reduces sensitivity, providing a more stable but slower adjustment to process deviations.

218. (A) Exchange operational status, diagnostic handshakes, and safety interlocks.
Industrial robotic control systems are integrated with programmable logic controllers via dedicated network connections to coordinate operations. This network interface enables the safe and rapid exchange of diagnostic handshakes, active operational status, and critical safety interlocks, ensuring that the robot and surrounding automation components operate in perfect synchronization.

219. (B) Using a 4 mA current signal to represent the 0% level, allowing detection of a broken wire.
The live zero concept in the industrial four-to-twenty milliampere current loop standard is a built-in safety feature. By using four milliamperes rather than zero to represent the minimum measurement level, the controller can easily distinguish between a valid zero reading and a complete physical break in the signal wire.

220. (B) A hybrid analog and digital communication protocol.
The Highway Addressable Remote Transducer protocol is classified as a hybrid analog and digital communication protocol. It preserves traditional point-to-point analog current signals while simultaneously allowing bidirectional digital communication over the same wiring. This hybrid design allows smart instruments to transmit process measurements alongside advanced diagnostics without requiring separate cabling.

221. (A) Reduced wiring complexity and lower installation costs using a single trunk cable.
Deploying a unified Fieldbus architecture instead of traditional point to point electrical hardwiring yields significant process benefits. By routing multiple digital signals over a single shared trunk cable, overall wiring complexity is greatly reduced. This substantial reduction in cabling material and labor requirements lowers initial installation costs while simplifying subsequent system maintenance.

222. (C) Messages with lower identifier values win arbitration and proceed without data loss.
The non-destructive arbitration method utilized in Controller Area Networks ensures efficient data transmission. When multiple nodes transmit simultaneously, the message with the lowest identifier value wins arbitration because its dominant bits override recessive bits. The winning node continues transmitting without delay or data corruption, ensuring deterministic communication for critical messages.

223. (D) Handling large data processing tasks, advanced visualization, and enterprise IT integration.
Computer-based industrial control systems excel in processing large volumes of data, generating advanced graphic visualizations, and integrating with enterprise information technology networks. While dedicated programmable logic controllers manage high-speed physical logic, computer hosts handle complex database queries, historical trending, and coordinate communications across different factory management software platforms.

224. (C) Unauthorized access to and remote control of critical public infrastructure.
A compromised supervisory control and data acquisition system poses severe risks.

Click Here to Buy book on Flipkart

physical actuators and override all active program logic.

187. (B) Advanced data computations, sensor scaling, and recipe management.
Compared to traditional simple relay logic, math instructions in programmable logic controllers enable advanced operations. By executing calculations such as addition, subtraction, multiplication, and division, controllers can scale raw analog sensor counts into physical engineering values, manage complex product recipe parameters, and perform real-time data computations vital for precise process automation.

188. (B) It can result in a watchdog timer timeout and fault the controller.
Utilizing a jump instruction to continuously loop backward in a programmable logic controller program creates an infinite execution loop. Since the processor is forced to repeatedly run the same block of code, it cannot complete its full scan cycle. This delay triggers the internal watchdog safety timer to time out, faulting the controller.

189. (A) Extracting or setting individual status flags packed within a single data word.
Bitwise manipulation is highly important in programmable logic controllers because industrial devices often consolidate status and alarm flags into single, multi-bit data words to optimize memory usage. Bitwise operations enable the processor to selectively extract, evaluate, or set these individual binary flags without modifying the surrounding data structure of the parent word.

190. (C) Array and data handling
The sequencer load instruction is categorized under array and data handling operations in programmable logic controllers. It is specifically designed to capture data from a physical input source and write it sequentially into a structured register array. This instruction facilitates complex tracking, diagnostic logging, and recipe formulation within automated assembly systems.

191. (D) The approximation of a continuous analog signal into discrete digital steps.
Quantization error in an analog programmable logic controller module occurs during the conversion process. Because an analog signal is infinitely variable, translating it into a digital representation requires dividing the continuous range into a finite number of discrete mathematical steps. The small difference between the actual physical value and the nearest digital step causes this error.

192. (C) Adjusting the proportional, integral, and derivative coefficients to optimize system response.
Loop tuning in a proportional-integral-derivative controller refers to the precise adjustment of the proportional, integral, and derivative coefficients. Modifying these control parameters optimizes the dynamic response of the closed-loop system, minimizing response delay, preventing excessive overshoot, and ensuring that the process variable quickly and stably aligns with the desired setpoint target.

193. (B) Differential voltage signaling to provide high noise immunity.
Industrial serial communication interfaces, such as RS-485, utilize differential voltage signaling across a twisted-pair cable. Instead of measuring a single signal voltage relative to a shared ground, the receiver measures the voltage difference between two dedicated lines. This differential approach provides exceptional immunity to electromagnetic noise and ground-loop electrical interference.

194. (D) 4 to 20 mA current loops
In the history of industrial instrumentation, pneumatic control systems operating on three-to-fifteen pounds per square inch of compressed air were widely phased out. They were replaced by electronic four-to-twenty milliampere current loops, which offer greater signal transmission speed, vastly reduced installation maintenance, simpler cabling, and easy integration with digital programmable controllers.

195. (A) It allows digital communication signals to superimpose on existing 4–20 mA analog wiring.
A major benefit of the Highway Addressable Remote Transducer protocol is its compatibility with existing factory infrastructure. It allows low-level, high-frequency digital communication signals to be superimposed directly onto legacy four-to-twenty milliampere analog current loop wiring. This capability enables modern smart diagnostics without requiring the replacement of existing copper cables.

Downloaded from www.pdf.tube

to fetch an instruction and read or write data concurrently during the same clock cycle, eliminating the bus bottleneck inherent in single-bus architectures.

178. (D) Integrated internal RC oscillators.
Many modern microcontrollers eliminate the requirement for external clock components, such as quartz crystals or ceramic resonators, by featuring integrated internal resistor-capacitor oscillators. These built-in timing circuits provide a sufficiently stable clock signal directly on the silicon die, reducing overall system component count, saving circuit board space, and lowering manufacturing costs.

179. (A) volatile - Prevents compiler optimization for variables that can change outside program flow.
In microcontroller C programming, the volatile keyword is an essential qualifier. It instructs the compiler to disable optimization for specific variables that may change unexpectedly outside the normal program flow, such as those modified by hardware interrupts or input pins. This ensures the processor reads the physical memory location every time the variable is accessed.

180. (C) The vector contains the memory address of the peripheral's Interrupt Service Routine (ISR).
The structural connection between a microcontroller peripheral and its interrupt vector is managed through memory mapping. An interrupt vector is a dedicated location in program memory that stores the exact execution address of the corresponding interrupt service routine. When a peripheral triggers an interrupt, the processor references this vector to execute the correct handler.

181. (A) Greater flexibility and scalability to add or mix different I/O and communication modules.
Modular programmable logic controllers offer a major advantage over fixed, shoebox-style units due to their expandable physical architecture. They provide superior flexibility and scalability, allowing engineers to mix, match, and add various specialized input, output, and communication modules on the backplane as system requirements expand or change over time.

182. (D) The module provides a low-potential path (common/ground) to complete the circuit for a load.
In industrial electronics, a sinking output module on a programmable logic controller functions by providing a low-potential connection to the system common or ground. When the output is activated, the internal semiconductor or relay completes the electrical path, allowing current to flow from a sourcing power supply, through the load, and down to ground.

NODIA

183. (C) 1,500 to 5,000 V
Optical isolators integrated into programmable logic controller input and output circuits are designed to withstand significant electrical surges. They typically provide high galvanic isolation, capable of withstanding voltage spikes ranging from fifteen hundred to five thousand volts. This protection ensures that severe field-side electrical faults do not damage the sensitive low-voltage microprocessor.

184. (C) A normally open relay contact
In basic ladder logic programming, the examine if closed instruction acts as the software equivalent of a physical normally open relay contact. The instruction evaluates as true when the monitored memory bit contains a value of one, indicating that the corresponding physical input terminal is receiving electrical power and its circuit is closed.

185. (D) The accumulated value is retained even when the rung goes false, preventing the timer from restarting on the next cycle.
A negative consequence of using retentive timer instructions without incorporating a dedicated reset instruction is that the accumulated time value remains stored in memory even when the enabling rung condition transitions to false. Consequently, the timer cannot restart its timing cycle from zero on subsequent program scans, stalling the sequential logic sequence.

186. (A) Master Control Relay (MCR) zone de-energization
To ensure a physical machine shuts down immediately when an emergency button is pressed, the master control relay instruction is the most appropriate selection. Activating the master control relay de-energizes an entire zone of non-retentive outputs instantly, bypassing standard rung conditions to safely disable

schedulers. It enables the precise execution of task switching, time delays, and real-time control algorithms within the embedded software.

206. (C) Conditional execution of complex mathematical instructions and subroutines.
Significant fluctuations in a programmable logic controller's scan cycle time are primarily caused by conditional code execution. When the program encounters true conditions that trigger complex floating-point mathematical computations, data array moves, or jump commands to large subroutines, the processor requires additional clock cycles, directly extending the duration of the scan.

207. (C) Direct current (DC) in a closed circuit.
The concepts of sourcing and sinking connections in industrial electronic circuits are governed by the conventional direction of direct current flow. Sourcing components act as the positive electrical supply, pushing current outward into the circuit. Sinking components provide the low-potential connection to the common ground, allowing direct current to flow out of the load.

208. (C) Minimizing electromagnetic interference (EMI) and crosstalk.
Shielded twisted-pair cabling is widely utilized in industrial programmable controller networks to protect communication signals. Twisting the conductor pairs ensures that induced electromagnetic noise affects both lines equally, allowing differential receivers to cancel it out. Additionally, the outer conductive shield blocks electrostatic noise and prevents signal crosstalk from adjacent cables.

209. (B) Intuitive graphical format easily understood by technicians familiar with electrical schematics.
A key advantage of relay ladder logic is its intuitive graphical format, which resembles traditional hardwired electrical schematic diagrams. This design allows plant technicians and industrial electricians to easily read, interpret, and debug control programs without needing extensive training in advanced text-based computer programming languages or complex software development.

210. (D) The accumulated value increments on a false-to-true transition of the rung.
In programmable logic controller programming, a count-up instruction monitors the status of its preceding rung conditions. The instruction's internal accumulated value increments by one each time the rung makes a transition from false to true. This edge-triggered behavior ensures the counter records distinct input events, such as physical objects passing a sensor.

211. (A) Using descriptive, programmer-defined variable names instead of absolute physical addresses.
Modern tag-based memory organization in programmable logic controllers eliminates the need for manual physical memory mapping. This architecture allows developers to create descriptive, programmer-defined variable names to represent data points. By decoupling the control program from fixed hardware register addresses, tag-based structures simplify code creation, modification, and long-term system maintenance.

212. (C) A major processor fault caused by attempting a division-by-zero operation.
Failing to implement limit comparison instructions prior to executing a division instruction in a programmable logic controller can cause severe operational issues. If the divisor variable drops to zero, the arithmetic logic unit will attempt a division-by-zero operation. This mathematically undefined calculation immediately triggers a major processor halt, stopping system operations.

213. (A) JSR - Directs program execution to a specified subroutine file.
In programmable logic controllers, flow control instructions manage the sequence of code execution. The jump to subroutine instruction is a primary tool that interrupts the standard linear scan of the main program, directing the processor to execute code within a specified subroutine file before returning to continue scanning the main routine.

214. (A) Both A and R are true and R is the correct explanation of A.
The bit shift right instruction is highly effective for tracking physical products on moving conveyor lines. When synchronized with conveyor movement, each false-to-true transition of the instruction shifts the data array bits one position to the right. This shifting pattern mirrors physical item advancement, allowing the tracking of defects at downstream stations.

Click Here to Buy book on Amazon

234. (A) The output is energized if at least one of the inputs is false.
A ladder logic rung containing two normally closed contacts in parallel implements a logical NAND function. The output coil is energized as long as at least one of the monitored inputs remains false, because the current path through that closed contact is maintained. The output de-energizes only when both inputs are true.

235. (B) A timer instruction that retains its accumulated value when the rung goes false and requires a RES instruction to clear.
The retentive timer is a specialized instruction that preserves its accumulated time value even when its enabling rung conditions transition to false. To clear this stored time and restart the timing sequence from zero, a separate reset instruction must be executed in the program, making it ideal for tracking cumulative equipment runtime.

236. (B) Using bit-level addressing syntax to specify the word and bit position.
To evaluate or modify a single data bit located within a sixteen-bit word, a programmable logic controller program utilizes bit-level addressing syntax. This notation specifies the exact address of the parent word followed by a unique delimiter and the numerical position of the targeted bit, allowing precise control of individual status flags.

237. (A) Larger potential destination limits due to rapid scaling of the product.
Compared to standard addition, executing a multiplication instruction in a programmable logic controller requires larger potential destination memory structures. Because multiplying two values scales the product rapidly, a standard register can easily overflow. Consequently, developers must allocate double-word or floating-point registers to safely store the resulting calculation.

238. (C) It makes the ladder logic difficult to read, debug, and maintain (spaghetti code).
Excessive use of jump instructions in a programmable logic controller program negatively impacts code quality. Bypassing multiple sections of code dynamically makes the logic difficult to read, troubleshoot, and maintain. This disorganized structure, often referred to as spaghetti code, increases the time required for engineering personnel to diagnose field issues.

239. (B) Masked Move (MVM)
The masked move instruction is designed to copy data from a source register to a destination register while filtering out specific bits. By using a defined mask pattern of ones and zeros, this instruction allows the processor to update only the designated bits in the destination while keeping all other bits unchanged.

240. (C) An instruction that controls sequential multi-step operations by stepping through an array of data words.
A sequencer output is a specialized programmable logic controller instruction used to manage complex sequential operations. It functions by stepping through a defined array of data words, writing the preprogrammed states to specified output registers. This structured approach simplifies the programming of machines that cycle through repeatable multi-step processes.

241. (B) The number of bits used by the Analog-to-Digital Converter (ADC).
Analog signal resolution in a programmable controller is determined by the bit capacity of the analog-to-digital converter. A higher bit depth divides the measured physical range into a greater number of discrete digital steps. Consequently, this increased resolution enables the controller to detect much smaller changes in process temperature or pressure.

NODIA

242. (D) A persistent error causes the integral term to accumulate to its limit because the actuator is fully open or closed (saturated).
Integral windup occurs in proportional integral derivative controllers when a continuous control loop error persists over a long operating period. Because the physical actuator is saturated and cannot open or close any further, the integral term continues to accumulate error. This large accumulation causes a major response delay when the process finally recovers.

243. (A) An open, standardized protocol such as Modbus TCP or EtherNet/IP over industrial Ethernet.
To successfully interconnect programmable logic controllers from different manufacturers into a unified factory network, using an open, standardized protocol is the most appropriate

Unauthorized access allows external adversaries to take remote control of physical field equipment. In critical applications, such as water treatment, electrical power distribution, or natural gas networks, this security failure can disrupt vital public services and cause severe hardware damage.

225. (B) Lose its ability to monitor and control remote physical assets.
Eliminating remote terminal units from a wide-area supervisory system would sever the primary link between the central controller and the field. The master terminal unit would lose its ability to gather data from distant environments and could no longer transmit control commands to physical actuators located at those remote sites.

226. (D) XOR
In digital design, the exclusive OR gate is the most appropriate logic block for constructing parity generators. Because an exclusive OR gate outputs a high signal only when its inputs contain an odd number of ones, cascading these gates allows the system to easily calculate and maintain odd or even parity bits.

227. (A) A unified memory space that allows flexible allocation between program code and data.
A primary advantage of the Von Neumann CPU architecture is its unified memory space. By storing both program instructions and data within a single physical memory unit, the architecture allows highly flexible memory allocation. This shared design simplifies hardware layout, as only a single memory bus is required to fetch instructions and data.

228. (C) The ALU updates condition flags (such as zero, carry, and overflow) in the status register.
In microcontroller CPUs, a close relationship exists between the arithmetic logic unit and the status register. Following the execution of any mathematical or logical instruction, the arithmetic logic unit updates specific condition flags within the status register, such as zero, carry, and overflow, to indicate the mathematical outcome.

229. (A) A short, human-readable abbreviation representing a machine instruction.
In computer programming, a mnemonic is a short, human-readable abbreviation that represents a specific machine instruction. Used in assembly language programming, mnemonics simplify coding by replacing complex binary instruction patterns with easily remembered words, such as ADD, SUB, or MOV, which are later translated into machine-executable code.

230. (D) Ports
To manage physical connections efficiently, a microcontroller's individual input and output pins are grouped together into organized structures called ports. These ports typically consist of eight or sixteen individual pins, allowing the central processing unit to read or write data to multiple pins concurrently using a single bus instruction.

231. (B) A dedicated area of memory that stores the status of physical inputs and outputs during the scan cycle.
A programmable logic controller's image table is a dedicated area of internal memory that buffers physical status data. At the start of each scan cycle, the controller copies the states of all physical inputs into this table. The logic program executes using these static values, updating output states before writing them back to physical terminals.

232. (C) An Analog-to-Digital Converter (ADC).
Processing continuous analog signals in a digital controller requires specialized conversion hardware. An analog input module must feature an analog-to-digital converter to sample physical signals, such as voltage or current, and translate them into proportional binary values. This digital representation can then be evaluated by the controller's processor.

233. (D) They use light to electrically isolate the internal CPU circuitry from high-voltage field signals.
Optical isolators provide a vital protective barrier in programmable logic controllers. By converting electrical input signals into light and transmitting them across an internal physical gap to a photodetector, these components electrically isolate the sensitive central processor. This physical isolation prevents dangerous high voltage spikes on field wiring from damaging internal computer circuitry.

Downloaded from www.pdf.tube

196. (C) Susceptibility to signal interference, packet loss, and security vulnerabilities.
By completely eliminating physical cable runs between controllers and instrumentation, wireless fieldbus networks introduce specific operational risks. These systems are inherently vulnerable to electromagnetic signal interference, packet transmission loss, and physical environmental obstructions. Additionally, transmitting data over the air increases susceptibility to critical cybersecurity threats, requiring robust data encryption and security measures.

197. (A) IV, II, I, III
A standard Controller Area Network data frame is organized into a highly structured sequence to manage bus access and verify data integrity. The transmission begins with the start of frame bit, followed directly by the arbitration field. Next, the data payload field is transmitted, and the frame concludes with the cyclic redundancy check field.

198. (D) DAQ systems convert physical environmental variables into digital signals for processing and analysis.
Data acquisition systems are engineered to measure physical phenomena and convert these environmental inputs into digital signals. The process begins with sensors translating physical properties into electrical outputs. The data acquisition hardware then conditions, filters, and digitizes these raw electrical signals using converters, enabling computers to record, analyze, and display the process data.

199. (B) Operator alarm fatigue and delayed critical response times.
Poorly designed supervisory control and data acquisition human-machine interfaces present serious operational hazards. When screens are overly cluttered or generate excessive non-critical alarms, operators suffer from alarm fatigue. This sensory overload degrades situational awareness, leading to delayed response times during critical system failures and increasing the likelihood of human error.

200. (C) Master Terminal Unit (MTU)
The master terminal unit is the most appropriate component to act as the primary communication hub in a wide-area supervisory control system. It coordinates telemetry communications across multiple distributed remote terminal units, periodically polling each remote site for diagnostic and process data while acting as the central interface for the supervisory database.

201. (D) An AND gate followed by a NOT gate.
In digital electronics, a NAND gate represents a fundamental logic function. It is constructed as the direct equivalent of a standard AND gate with its output inverted by a NOT gate. Consequently, the output remains high for all input combinations, transitioning to low only when every single input is high simultaneously.

202. (A) A central processing unit on a single integrated circuit that requires external memory and peripherals.
A microprocessor is a highly integrated circuit containing the primary central processing unit of a computer system. Unlike a microcontroller, which integrates memory and input-output hardware on a single silicon die, a microprocessor requires external components, such as random-access memory, flash storage, and peripheral interface controllers, to function as a complete computer system.

NODIA

203. (B) 8 bits
A standard eight-bit microcontroller is designed with an arithmetic logic unit that natively processes data blocks of eight bits in size. While the processor can execute operations on larger datasets using multi-cycle software instructions, its internal data bus, general-purpose registers, and native mathematical execution hardware are optimized for eight-bit data words.

204. (B) The operand value itself is contained directly within the instruction code.
In computer CPU architectures, immediate addressing is a fast execution mode where the operand value is embedded directly within the instruction code itself. Because the processor does not need to calculate a memory address or access registers to fetch the target data, this addressing mode minimizes cycle times and is ideal for loading constants.

205. (A) It can be used to generate a highly stable real-time system tick for scheduler operations.
When a microcontroller timer interrupt is configured to execute precisely every millisecond, it provides a highly stable time reference. This periodic interrupt, commonly referred to as a system tick, is vital for operating system

approach. Standards such as Modbus TCP or EtherNet IP over industrial Ethernet facilitate highly reliable communication and data sharing, avoiding the high cost and complexity of proprietary network gateways.

244. (C) Greater noise immunity and less signal degradation over long distances.
The four to twenty milliampere current loop offers significant advantages over zero to ten volt signals in industrial environments. Because current is constant throughout a closed loop, the signal does not suffer from voltage drops over long transmission distances. Additionally, current loops exhibit superior immunity to electromagnetic interference and electrostatic noise.

245. (A) Universal Commands - Functions implemented by all HART-compliant field devices.
Within the structural framework of the Highway Addressable Remote Transducer protocol, universal commands represent the primary instructional layer. These standardized commands are fully implemented by all HART compliant field devices regardless of manufacturer. They allow basic diagnostic information, such as primary variable readings and device manufacturer identification, to be retrieved consistently.

246. (D) The host system to understand and configure a device's specific parameters and variables.
Device description files in industrial Fieldbus networks function as standardized driver files. They provide the central host configuration system with the necessary parameters, variables, and menu structures of a connected field instrument. This descriptor data ensures the master controller can successfully understand, calibrate, and monitor the device's specific features.

247. (B) The identifier length (11 vs. 29 bits).
The distinction between standard and extended Controller Area Network frames lies within the structure of the arbitration field. A standard CAN frame uses an eleven-bit identifier, whereas an extended CAN frame features a twenty-nine-bit identifier. This expanded identifier allows for a vastly increased number of unique message classifications on the bus.

248. (C) The system requires high availability and continuous operation in the event of hardware failure.
Implementing dual-redundant master terminal units in a supervisory system indicates that the application requires extremely high availability. By pairing two controllers in a standby configuration, a hardware failure on the primary unit triggers an automatic, seamless failover. This configuration prevents process interruption and ensures continuous monitoring of critical infrastructure.

249. (D) A specific request or poll command received from the Master Terminal Unit (MTU).
In a standard poll response supervisory system, a remote terminal unit remains silent to prevent network collisions. It initiates data transmission only after receiving a specific request or polling command from the master terminal unit. This master slave coordination structure prevents multiple remote units from transmitting simultaneously, optimizing overall network bandwidth.

250. (A) It can saturate the communication bandwidth, leading to packet drops and delayed critical alarms.
Utilizing an excessively high polling frequency in a supervisory system operating over limited bandwidth can quickly saturate the physical communication network. This congestion leads to packet transmission drops, increased latency, and delayed critical system alarms. Consequently, systems must balance polling cycles to ensure timely data updates without overloading the telemetry links.

251. (B) A highly visual, circuit-like graphical representation that matches electrical schematics.
Compared to standard text based Boolean algebra, ladder logic provides a highly visual, circuit like graphical programming interface. This representation directly mirrors the look of traditional hardwired electrical schematic diagrams. This intuitive graphical layout makes it much easier for plant electricians and maintenance staff to understand, troubleshoot, and modify complex control routines.

252. (B) Be unable to perform basic arithmetic or logical operations.
Eliminating the arithmetic logic unit from a microprocessor would completely disable

Click Here to Buy book on Flipkart

its primary computational capabilities. The processor would be unable to execute basic mathematical additions, subtractions, or perform fundamental bitwise logical comparisons. It would function merely as a simple data transfer device, incapable of running operating programs or control algorithms.

253. (A) Control unit and decoding circuitry.
Within a central processing unit, the instruction register is classified under the control and decoding circuitry. When an instruction is fetched from memory, it is temporarily stored in this register. The control unit then decodes the instruction code to coordinate the necessary data paths and execution cycles of the processor.

254. (C) Writing to specific Special Function Registers (SFRs) mapped to the pins.
Writing programs for microcontrollers in C requires directly interacting with the hardware layer. To read or manipulate physical input and output pins, developers write values to designated special function registers. These memory-mapped registers act as the direct control interface between the software program and the physical pins on the chip.

255. (D) Varying the duty cycle of a constant-frequency square wave to simulate an analog output.
Pulse width modulation is a common peripheral feature in microcontrollers used to simulate an analog output signal. By rapidly turning a digital output pin on and off at a constant frequency, the processor varies the duty cycle. This variation adjusts the average voltage delivered to the load, controlling motors or dimming lights.

256. (C) A shorter scan time reduces the latency in detecting and responding to input changes.
The duration of a programmable logic controller's scan cycle directly affects its overall input responsiveness. A shorter scan time ensures that the processor reads physical input terminals more frequently. This rapid scanning reduces the physical latency between an input transition in the field and the execution of the corresponding output logic.

257. (B) Semiconductor devices such as transistors or triacs.
Solid-state discrete outputs in programmable logic controllers utilize semiconductor devices, such as transistors for direct current or triacs for alternating current. Since these components lack moving contacts, they switch outputs rapidly and offer virtually infinite life cycles, making them ideal for high-speed switching applications compared to electromechanical relays.

258. (D) Superior filtering of electrical noise, robust voltage regulation, and tolerance to thermal stress.
Utilizing a dedicated programmable logic controller power supply provides major benefits over standard commercial power adapters. These industrial units feature superior electrical noise filtering, extremely tight voltage regulation, and high resistance to thermal stress. This robust design protects sensitive internal controller circuitry from voltage surges and harsh industrial environments.

259. (A) The output coil is continuously energized during controller RUN mode.
When a programmable logic controller rung contains an output coil instruction without any preceding input conditional instructions, the rung has continuous logical continuity. Consequently, the processor will continuously energize the output coil during every execution scan while the controller remains configured in run mode, regardless of other conditions.

260. (C) A false-to-true transition of the rung logic.
A standard count down instruction in a programmable logic controller decrements its internal accumulated value by one each time it detects a transition. Specifically, this reduction occurs on a false to true transition of the preceding rung logic. This edge triggered behavior allows the counter to precisely track individual physical process events.

NODIA

261. (A) Data types and physical addresses are assigned to named tags rather than fixed memory registers.
Modern tag-based programmable logic controller memory architectures assign data types and physical addresses directly to named variables, known as tags. Rather than forcing programmers to reference fixed, absolute memory registers, this system allows descriptive named tags to represent physical data points, simplifying program development and enhancing system compatibility across different engineering platforms.

262. (D) Precision and rounding errors may prevent two values from being exactly equal, causing the instruction to evaluate as false.
Using an equal comparison instruction with floating-point values can lead to unexpected errors due to precision and rounding limitations. Because binary representations of floating-point numbers can vary slightly, two values may not be exactly identical. Consequently, the comparison can evaluate as false, making limit comparison instructions far more reliable.

263. (B) The main program uses call instructions to execute subroutines for modular or repetitive tasks.
The structural connection between a main program and subroutines facilitates modular software design. The main routine executes sequentially and utilizes jump-to-subroutine call instructions to run specific subroutines for repetitive or specialized tasks. Once the subroutine finishes, execution control returns directly to the next instruction in the main program.

264. (C) FLL (File Fill)
To efficiently reset a large, contiguous block of memory to zero or any other constant, the file fill instruction is the most appropriate selection. It is designed to copy a source value into a specified range of destination registers in a single scan, simplifying memory initialization routines.

265. (D) Performing logical or comparison operations on entire arrays of data words simultaneously.
Matrix operations in programmable logic controllers offer significant data processing benefits compared to standard bit level logic. These instructions enable the controller processor to perform logical comparisons or data transfer operations across entire arrays of multi bit data words concurrently. This multi word processing optimizes logic scan times and simplifies complex system diagnostics.

266. (A) Analog data manipulation
Signal scaling in programmable logic controllers is classified under analog data manipulation. Raw binary counts from analog input cards represent physical sensor measurements. The scaling algorithm applies mathematical formulas to convert these counts into human readable engineering units, enabling highly precise monitoring and execution of control decisions based on actual physical data.

267. (B) Eliminate steady-state error (offset).
Eliminating the integral term from a proportional-integral-derivative controller, converting it to a proportional-derivative controller, removes its ability to correct steady-state offset. While the proportional and derivative terms respond to immediate errors and rate of change, only the integral term continuously accumulates historical error to completely eliminate residual deviations from the setpoint.

268. (B) The rate at which the communication channel transitions between signal states.
In industrial networking, the term baud rate represents the speed of signal transmission across a communication channel. It specifically measures the rate at which the physical line transitions between distinct electrical or optical signal states per second. This rate directly influences the overall bandwidth and communication speed of the network.

NODIA

269. (A) Perform self-diagnostics, calibration, and bidirectional digital communication.
Smart instruments utilizing the Highway Addressable Remote Transducer or other Fieldbus protocols provide advanced features. These microchip-enabled devices are capable of performing internal self-diagnostics, executing remote calibrations, and maintaining bidirectional digital communications. This intelligence allows operators to monitor sensor health and access detailed diagnostics without visiting the physical field location.

270. (C) Connecting multiple field devices in parallel on a single wire pair, with communication occurring entirely via digital polling.
Multidrop configuration in Highway Addressable Remote Transducer networks allows multiple field instruments to be connected in parallel across a single twisted-pair wire. In this mode, individual analog signals are disabled, and the loop current is fixed. Communication occurs entirely via digital polling, allowing a single host to monitor multiple devices.

****

2023
21. Pneumatic actuation is often favored for agricultural fruit-picking end-effectors because of which inherent characteristic?
(A) Infinite positional resolution
(B) Natural compliance and softness
(C) High operating fluid mass
(D) Suitability for heavy payload lifting

2003
22. What is a primary disadvantage of standard hydraulic robotic actuators compared to electrical servomotors?
(A) Significantly lower power-to-weight ratios in normal operations
(B) Complete inability to hold a static load without active power
(C) Risk of high-pressure fluid leakage contaminating the crop
(D) Excessive electromagnetic and electrical signal interference

2002
23. Electrical drive systems in modern robotics predominantly use which type of motor for high-precision joint control?
(A) AC induction motors
(B) DC permanent magnet stepper motors
(C) Switched reluctance motors
(D) Brushless DC servomotors

2002
24. Which performance metric is generally highest in pneumatic actuators?
(A) Operating speed
(B) Positional accuracy
(C) Maximum force capacity
(D) Energy efficiency

2008
25. Match List I with List II.
List I: (Actuator Type)
P. Hydraulic
Q. Pneumatic
R. Stepper Motor
S. BLDC Motor
List II: (Characteristic)
1. Open-loop positioning
2. High power-to-weight ratio
3. High efficiency continuous rotation
4. High compliance
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-1, R-4, S-3

2025
26. In matrix algebra applied to robotics, what condition must hold for a matrix to be considered an orthogonal rotation matrix?
(A) Its calculated determinant must be exactly equal to zero
(B) Its inverse must be equal to its mathematical transpose
(C) It must be represented as a standard four-by-four matrix
(D) Its diagonal trace value must be mathematically equal to one

2001
27. The determinant of any valid 3×3 rotation matrix is always equal to what value?
(A) -1
(B) 0
(C) 1
(D) 3

2018
28. Which operation is mathematically equivalent to the inverse of a spatial translation vector?
(A) Taking the transpose of the vector
(B) Multiplying the vector by a rotation matrix
(C) Negating the components of the vector
(D) Calculating the cross product of the vector

2007
29. A basic rotation matrix describing a rotation of angle θ about the Z-axis contains which of the following terms?
(A) Both $\cos(\theta)$ and $\sin(\theta)$ terms located in the third row
(B) Zeros in the first row except for a value of 1 in the (1,1) position
(C) A negative term $-\cos(\theta)$ located in the (2,2) position
(D) Zeros in the third row except for a 1 in the (3,3) position

2015
30. Which rotational property correctly states that finite sequential rotations in 3D space are non-commutative?
(A) $R_x(\alpha)\,R_y(\beta) = R_y(\beta)\,R_x(\alpha)$
(B) $R_x(\alpha) = -\,R_y(\alpha)$
(C) $R_x(\alpha)\,R_y(\beta) \neq R_y(\beta)\,R_x(\alpha)$
(D) $R_x(\alpha)\,R_x(\beta) \neq R_x(\alpha+\beta)$

2019
31. What is the minimum number of independent parameters required to fully describe the orientation of a rigid body in 3D space?
(A) 2

Downloaded from www.pdf.tube

(C) It defines the position of the end-effector
(D) It reduces the required degrees of freedom

2008

11. Which configuration provides the highest structural rigidity and payload capacity over a large rectangular area?
(A) Gantry robot
(B) SCARA robot
(C) Spherical robot
(D) Delta robot

2025

12. Spatial resolution in a robotic manipulator is mathematically defined as the sum of which two components?
(A) Dynamic precision and absolute positioning accuracy
(B) Command control resolution and positional repeatability
(C) Control resolution and mechanical link inaccuracy
(D) Target accuracy and robotic joint repeatability

2021

13. Which concept describes the ability of a robotic manipulator to return to a previously taught position over multiple attempts?
(A) Accuracy
(B) Spatial resolution
(C) Kinematic singularity
(D) Repeatability

2025

14. If a robot's joints are driven by a 10-bit encoder, how many discrete positions can the controller command for a single full rotation?
(A) 256
(B) 512
(C) 1024
(D) 2048

2016

15. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): A robotic manipulator with high repeatability always exhibits high accuracy.
Reason (R): Repeatability measures the variance of positional errors, whereas accuracy measures the deviation from the exact target coordinate.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2011

16. Control resolution in a multi-axis manipulator is directly determined by the bit capacity of the control memory and what other factor?
(A) The overall total mass of the entire manipulator assembly
(B) The specific payload capacity of the end-effector tool
(C) The maximum operational speed of the programmed trajectory
(D) The physical range of motion of the specific joint

2016

17. Which error source predominantly degrades a robot's mechanical accuracy but NOT its repeatability?
(A) Thermal expansion of the robotic links
(B) Worn gear backlash
(C) Inconsistent encoder pulses
(D) Misaligned target coordinates in the programming phase

NODIA

2008

18. Why do agricultural robots often require different kinematic control metrics compared to indoor industrial robots?
(A) Agricultural robots require fewer degrees of freedom
(B) Indoor robots do not utilize inverse kinematics
(C) Soil conditions cause unpredictable base shifts
(D) Plant growth is highly uniform and static

2011

19. Precision in robotic positioning is most closely related to which statistical parameter of the target approaches?
(A) The standard deviation of the positions
(B) The mathematical mean of target positions
(C) The calculated median of actual positions
(D) The absolute maximum positioning error

2013

20. Which actuator technology is typically selected when an agricultural robot requires extreme force output within a compact envelope?
(A) Direct-drive electrical motors
(B) Pneumatic cylinders
(C) Shape memory alloys
(D) Hydraulic actuators

2025

42. Compound transformations are calculated by multiplying successive matrices. If transformations are defined relative to the current moving frame, in what order are the matrices multiplied?
(A) Post-multiplication (multiplying on the right of the existing transformation matrix)
(B) Pre-multiplication (multiplying on the left of the existing transformation matrix)
(C) Element-wise multiplication of the matrices
(D) Direct addition of the translation vectors only

2013

43. Homogeneous coordinates represent a 3D vector $[x, y, z]^T$ by augmenting it. What is the resulting augmented vector?
(A) $[x, y, z, 1]^T$
(B) $[x, y, z, 0]^T$
(C) $[x, y, z, x + y]^T$
(D) $[w, x, y, z]^T$

2021

44. An agricultural robotic arm applies a sensor on a leaf. If the sensor frame is known relative to the end-effector, and the end-effector is known relative to the base, which mathematical operation yields the sensor frame relative to the base?
(A) Sequential matrix subtraction
(B) Standard matrix addition
(C) Matrix multiplication
(D) Vector cross product

2004

45. Consider the following statements regarding homogeneous transformation matrices:
I. The inverse of the rotation submatrix is its transpose.
II. The translation vector is invariant under inversion of the full 4×4 matrix.
III. The bottom row is always $[0\,0\,0\,1]$ for rigid body kinematics.
IV. Pre-multiplying corresponds to transformations relative to fixed axes.
Which of the above statements is/are INCORRECT?
(A) II
(B) I and III
(C) I, II and IV
(D) I and IV

2025

46. The Denavit-Hartenberg (D-H) convention systematically assigns coordinate frames to robotic links. How many parameters are required per link?
(A) 2
(B) 3
(C) 4
(D) 6

2008

47. In the standard D-H convention, the link length a_i is defined as the distance between which two axes?
(A) $X_{\{i-1\}}$ and X_i along the Z_i axis
(B) $Z_{\{i-1\}}$ and Z_i along the X_i axis
(C) $Z_{\{i-1\}}$ and Z_i along the Y_i axis
(D) $Y_{\{i-1\}}$ and Y_i along the X_i axis

2006

48. Which D-H parameter corresponds to the joint variable for a prismatic joint?
(A) The physical link length (a_i)
(B) The relative link twist angle (α_i)
(C) The rotational joint angle (θ_i)
(D) Joint distance (d_i)

2023

49. According to D-H parameter assignment rules, the X_i axis must be defined perpendicular to which axis?
(A) $Z_{\{i-1\}}$
(B) $X_{\{i-1\}}$
(C) Y_i
(D) $Y_{\{i-1\}}$

2018

50. The link twist parameter α_i in the D-H convention describes the angle between which two axes?
(A) $X_{\{i-1\}}$ and X_i measured about the $Z_{\{i-1\}}$ axis
(B) $Y_{\{i-1\}}$ and Y_i measured about the Z_i axis
(C) $Z_{\{i-1\}}$ and Z_i measured about the X_i axis
(D) $Z_{\{i-1\}}$ and X_i measured about the Y_i axis

2001

51. What is the fundamental advantage of utilizing the D-H convention in agricultural manipulator design?
(A) It standardizes the derivation of forward kinematics
(B) It completely eliminates the need for inverse kinematics calculations
(C) It automatically compensates for mechanical joint backlash errors
(D) It restricts the robotic manipulator to planar movements only

Click Here to Buy book on Amazon

(B) 3
(C) 4
(D) 6

2023

32. Euler angles are defined by sequential rotations about moving axes. Which sequence represents the standard Z-Y-X Euler angle convention?
(A) Rotation about the Z axis, followed by fixed Y, and then fixed X
(B) Rotation about the X axis, followed by current Y, and then current Z
(C) Rotation about the fixed X axis, the fixed Y, and the fixed Z axis
(D) Rotation about Z, then current Y, then current X

2004

33. The Roll-Pitch-Yaw (RPY) convention typically corresponds to successive rotations about which types of coordinate axes?
(A) Fixed reference frame axes
(B) Moving reference frame axes
(C) A single arbitrary rotation axis
(D) Non-orthogonal coordinate axes

2022

34. Gimbal lock is a mathematical singularity that occurs when using Euler angles. What physical situation does it represent?
(A) The mechanical manipulator reaches its maximum allowable payload carrying capacity
(B) The calculated rotation matrix determinant mathematically becomes a value of zero
(C) Two rotational axes align, resulting in the loss of one degree of freedom
(D) The spatial translation vector approaches an infinite value in the workspace

2008

35. Consider the following statements regarding rigid body orientation:
I. Roll-Pitch-Yaw angles represent rotations about fixed axes.
II. Unit quaternions require exactly 3 parameters.
III. Euler angles can suffer from representational singularities.
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) II
(D) II and III

2025

36. If an agricultural drone experiences a "pitch" motion, about which axis is it rotating relative to its body frame?
(A) The longitudinal roll-stabilizing axis
(B) The vertical yaw-stabilizing axis
(C) The diagonal non-standard axis
(D) The transverse (lateral) axis

2018

37. To prevent gimbal lock in complex trajectory planning for autonomous tractors, which mathematical representation is commonly utilized?
(A) 3×3 Skew-symmetric matrices
(B) Unit quaternions
(C) Z-Y-Z Euler angles
(D) Denavit-Hartenberg parameters

2004

38. A homogeneous transformation matrix combines translation and rotation into a single matrix. What is its dimension for 3D space?
(A) 3×3
(B) 3×4
(C) 4×4
(D) 6×6

NODIA

2006

39. In a standard homogeneous transformation matrix, what does the top-right 3×1 submatrix represent?
(A) The rotational component
(B) The perspective transformation
(C) The uniform scaling factor
(D) The translation vector

2004

40. What value occupies the bottom-right element (position 4,4) of a standard rigid-body homogeneous transformation matrix?
(A) -1
(B) 0
(C) 1
(D) π

2009

41. If matrix T_A^B represents the homogeneous transformation from frame A to frame B, how is the transformation from frame B to frame A obtained?
(A) By taking the transpose of T_A^B
(B) By taking the inverse of T_A^B
(C) By multiplying T_A^B by -1
(D) By replacing the translation vector with zeros

(A) Highly redundant manipulator configurations with seven or more joint axes
(B) Parallel delta robot architectures used in industry
(C) Standard planar systems or arms with intersecting wrist axes
(D) Spatial robotic manipulators designed without prismatic joints

2017

63. How many unique inverse kinematic solutions typically exist for an elbow manipulator (like PUMA) to reach a general pose?
(A) 1
(B) 2
(C) 4
(D) 8

2005

64. When an inverse kinematics algorithm fails to find a real number solution, what physical state does this indicate about the manipulator?
(A) The manipulator is operating at its absolute maximum velocity
(B) The kinematic structure of the manipulator is in a singular state
(C) The physical control resolution of the encoder has been exceeded
(D) The target point lies outside the reachable workspace

2012

65. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Inverse kinematics for a 6 DOF manipulator is guaranteed to have a closed-form analytical solution if three consecutive revolute joint axes intersect at a single point.
Reason (R): The intersection allows the problem to be decoupled into separate inverse position and inverse orientation problems.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2006

66. The technique of decoupling inverse kinematics using a spherical wrist mechanism heavily relies on calculating which intermediate point?
(A) Base origin
(B) End-effector tool tip
(C) Wrist center
(D) Center of mass

2017

67. The Jacobian matrix of a robotic manipulator primarily relates which two domains?
(A) Joint velocities to end-effector velocities
(B) Individual joint torques to end-effector contact forces
(C) Spatial link masses to equivalent rotational body inertias
(D) Static position coordinates to transformation matrix values

2008

68. For a 6-DOF robotic arm, what are the standard dimensions of its full spatial Jacobian matrix?
(A) 3×6
(B) 4×4
(C) 6×3
(D) 6×6

2015

69. A kinematic singularity occurs when the determinant of the Jacobian matrix equals what value?
(A) -1
(B) 0
(C) 1
(D) Infinity

2005

70. What physically happens to a robotic manipulator at a kinematic singularity boundary?
(A) The mechanical manipulator moves at a theoretically infinite velocity
(B) The individual joints completely disengage from their actuators
(C) The manipulator loses one or more degrees of freedom
(D) The overall reachable workspace volume of the robot doubles

2001

71. Acceleration analysis in velocity kinematics involves taking the time derivative of which component?
(A) The forward kinematics positional vector
(B) The D-H parameters
(C) The link inertia tensor
(D) The Jacobian matrix equation

2022

72. Which portion of the Jacobian matrix governs the angular velocity of the end-effector?
(A) The lower 3 rows

Downloaded from www.pdf.tube

2012

52. When two consecutive joint axes $Z_{\{i-1\}}$ and Z_i intersect, what is the value of the D-H parameter a_i?
(A) Infinity
(B) One
(C) Equal to d_i
(D) Zero

2019

53. Which sequence correctly represents the order of basic transformations forming the standard D-H matrix A_i?
(A) Trans(X), Rot(X), Trans(Z), Rot(Z)
(B) Rot(Z), Trans(Z), Trans(X), Rot(X)
(C) Rot(X), Trans(X), Rot(Z), Trans(Z)
(D) Trans(Z), Rot(Z), Rot(X), Trans(X)

2005

54. Forward kinematics is best defined as the process of determining which of the following?
(A) The joint angles required to reach a specific end-effector position
(B) The dynamic forces acting on each link
(C) The end-effector pose given the individual joint parameters
(D) The optimal trajectory between two points

2003

55. Consider the following statements about forward kinematics of a 2R planar manipulator:
I. The end-effector position only depends on the link lengths and joint angles.
II. The problem always has multiple unique solutions.
III. The orientation of the end-effector is simply the sum of the joint angles.
IV. The workspace is a 3D spherical volume.
V. It employs simple trigonometric projection onto the X and Y axes.
Which of the above statements is/are correct?
(A) I, III and V
(B) I, II, III and V
(C) I, IV and V
(D) I, III, IV and V

2012

56. For a planar 3R robotic manipulator, how many degrees of freedom does the end-effector possess within the plane?
(A) 2
(B) 3
(C) 4
(D) 6

2004

57. A spatial 3P configuration represents which common industrial robot architecture?
(A) Articulated manipulator arm
(B) Cartesian gantry
(C) SCARA assembly robot
(D) Spherical coordinate robot

NODIA

2018

58. The forward kinematics of a standard 6R manipulator typically involves computing the product of how many D-H transformation matrices?
(A) 3
(B) 5
(C) 6
(D) 12

2018

59. In the forward kinematics of a 2R planar arm with link lengths L_1 and L_2, what is the X-coordinate of the end-effector?
(A) $L_1\cos(\theta_1) + L_2\cos(\theta_1+\theta_2)$
(B) $L_1\sin(\theta_1) + L_2\sin(\theta_1+\theta_2)$
(C) $L_1\cos(\theta_1) \cdot L_2\cos(\theta_2)$
(D) $L_1\theta_1 + L_2\theta_2$

2022

60. Inverse kinematics is generally more difficult than forward kinematics because of which mathematical characteristic?
(A) The governing kinematics equations are always perfectly linear in form
(B) There is guaranteed to be exactly one unique analytical solution
(C) It involves solving non-linear joint equations
(D) The underlying matrix multiplication is fundamentally non-associative

2009

61. Algebraic approaches to inverse kinematics involve manipulating which equations to isolate joint variables?
(A) The dynamic Newton-Euler equations of motion
(B) The singular Jacobian matrix determinant values
(C) The scalar Lagrangian energy formulation equations
(D) The individual transformation matrix elements

2006

62. Geometric methods for inverse kinematics are particularly highly effective for which type of manipulator?

reaction forces
(B) Fully populated robotic Jacobian matrices
(C) Link velocities and accelerations
(D) Multi-axis inverse kinematics coordinates

2025
83. The backward iteration in the recursive Newton-Euler method computes which parameters moving from the end-effector to the base?
(A) Forces and joint torques
(B) Spatial kinematic joint positions
(C) Rotational angular joint velocities
(D) Sequence-dependent Euler angles

2024
84. The Lagrangian formulation of manipulator dynamics relies on scalar energy terms. Which two energies are utilized?
(A) Thermal and Mechanical energy
(B) Electrical and Magnetic energy
(C) Strain and Elastic energy
(D) Kinetic and Potential energy

2018
85. Select the correct sequence of steps for deriving manipulator dynamics using the Lagrangian formulation.
(A) Form Lagrangian, Apply Euler-Lagrange equations, Calculate Potential Energy, Calculate Kinetic Energy
(B) Calculate Kinetic Energy, Calculate Potential Energy, Form Lagrangian, Apply Euler-Lagrange equations
(C) Apply Euler-Lagrange equations, Form Lagrangian, Calculate Kinetic Energy, Calculate Potential Energy
(D) Calculate Potential Energy, Form Lagrangian, Calculate Kinetic Energy, Apply Euler-Lagrange equations

2010
86. In the Lagrangian equation $L = K - P$, what does K represent?
(A) Constant of proportionality
(B) Potential energy
(C) Kinetic energy
(D) Joint stiffness

2006
87. The closed-form dynamic equations derived from the Lagrangian method often express joint torques as a function of which specific terms?
(A) Joint position, ambient temperature, and feedback electrical current
(B) Total link mass, mechanical friction coefficient, and base coordinates
(C) Joint structural elasticity, physical damping, and pneumatic pressure
(D) Inertia, Coriolis/centrifugal forces, and gravity

2002
88. Coriolis forces in a robotic manipulator's dynamic model arise mathematically due to the interaction of what?
(A) Joint-velocity interactions
(B) Gravitational acceleration acting on the static manipulator links
(C) The mathematical square of a single isolated joint's velocity
(D) Viscous and static friction present in the actuator bearings

2025
89. Dynamic simulation of a robotic system requires solving which mathematical problem to predict motion given applied torques?
(A) Forward kinematics
(B) Forward dynamics
(C) Inverse kinematics
(D) Inverse dynamics

2019
90. Consider the following statements concerning the Lagrangian vs. Newton-Euler formulations:
I. Lagrangian is energy-based and scalar.
II. Newton-Euler is force/torque-based and vectorial.
III. Newton-Euler equations cannot be solved numerically.
Which of the above statements is/are correct?
(A) I and III
(B) I and II
(C) II and III
(D) II

2018
91. In point-to-point (PTP) trajectory planning, what is the primary concern for the robot controller?
(A) Reaching the final target destination
(B) Maintaining a perfectly straight linear path between two coordinate points
(C) Avoiding any sudden acceleration or deceleration phases during movement
(D) Keeping all active joint velocities strictly identical during the motion

2018
92. Continuous path (CP) execution is mandatory for which of the following agricultural applications?
(A) Placing a single seed precisely in a predefined

Click Here to Buy book on Flipkart

(B) The upper 3 rows
(C) The diagonal elements
(D) The inverse Jacobian

2003

73. If an agricultural robot needs to maintain a constant Cartesian speed while spraying a crop, which mathematical entity must be continuously updated to command the varying joint speeds?
(A) The forward kinematics equations
(B) The inverse Jacobian matrix
(C) The inertia tensor
(D) The rotational Euler sequence

2015

74. Rigid body dynamics focuses on the relationship between forces/torques and which corresponding outcome?
(A) Static positional accuracy under high load
(B) Generated link motion and accelerations
(C) Temperature variations in the electric drive motors
(D) Signal-to-noise ratio in analog sensor communication lines

2023

75. Match List I with List II.
List I: (Kinematic/Dynamic Concept)
P. Kinematic Singularities
Q. Orientations
R. Joint/Cartesian Velocity mapping
S. Positional Transformations
List II: (Mathematical Entity)
1. Jacobian Matrix
2. Determinant of Jacobian
3. Homogeneous Matrix
4. Rotation Matrix
(A) P-2, Q-4, R-1, S-3
(B) P-1, Q-3, R-2, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-1, R-4, S-3

2022

76. The center of mass of a rigid robotic link simplifies dynamic calculations by acting as what?
(A) The physical point where all external joint friction forces are applied
(B) The absolute origin coordinate of the fixed robotic base frame
(C) The point where the link's mass is concentrated
(D) The theoretical point exhibiting the absolute maximum velocity

2005

77. The moment of inertia tensor for a general 3D rigid body is represented by a symmetric matrix of what dimension?
(A) 2×2
(B) 3×3
(C) 4×4
(D) 6×6

2019

78. Which elements of the inertia tensor represent the mass symmetry and mass distribution off the principal axes?
(A) The principal moments of inertia
(B) The vector sum of forces
(C) The products of inertia
(D) The eigenvalues

2022

79. When a coordinate system aligns with the principal axes of an object, what becomes true about the inertia tensor?
(A) It becomes the identity matrix
(B) All products of inertia become zero
(C) It becomes completely populated with non-zero values
(D) The mass is assumed to be zero

2016

80. The Newton-Euler dynamic formulation is based on a fundamental principle of mechanics. Which equation describes the rotational component?
(A) The basic linear relation $F = ma$
(B) The standard formulation of D'Alembert's principle
(C) The mechanical work-energy conservation theorem
(D) Euler's equation of motion

2008

81. What is a key computational advantage of the Newton-Euler dynamic formulation over other methods?
(A) It suits recursive numerical algorithms
(B) It generates purely closed-form symbolic equations of motion
(C) It completely ignores the dynamic effects of gravitational forces
(D) It does not require calculating the precise link center of mass

2001

82. In the recursive Newton-Euler formulation, the forward iteration computes which physical parameters from the base to the end-effector?
(A) Calculated joint torques and internal

Downloaded from www.pdf.tube

CHAPTER 10
Robot Design and Control

2024
1. What primary characteristic distinguishes an industrial robot from conventional hard automation in an agricultural context?
(A) Its reprogrammability for diverse agricultural tasks
(B) Its use of rigid mechanical linkages for articulation
(C) Its integration of specialized hydraulic fluid systems
(D) Its reliance on continuous manual steering and control

2011
2. Which historical robot is widely recognized as the first commercially successful industrial robot?
(A) Shakey
(B) PUMA
(C) Unimate
(D) SCARA

2001
3. In the context of emerging trends in agricultural robotics, which technology facilitates simultaneous plant health monitoring and localized chemical application?
(A) Precision variable-rate technology
(B) High-pressure pneumatic controller systems
(C) Fixed-path mechanical weed control systems
(D) Single-axis Cartesian gantry mechanisms

2018
4. Which term best describes the process where an agricultural robot adjusts its real-time operation based on continuously updated field data?
(A) Static calibration
(B) Deterministic sequencing
(C) Open-loop execution
(D) Adaptive control

2003
5. Identify the INCORRECT statement regarding the evolution of agricultural automation.
(A) Early automation primarily relied on mechanical linkages and complex cams
(B) Modern agricultural robots operate exclusively in highly structured environments
(C) The introduction of microprocessors enabled dynamic trajectory adjustments
(D) Current trends heavily incorporate advanced machine vision for identification

NODIA

2014
6. A Cartesian robot configuration is characterized by which types of joint arrangements?
(A) Three rotary joints
(B) Two rotary joints and one prismatic joint
(C) Three prismatic joints
(D) One rotary joint and two prismatic joints

2011
7. The SCARA robot configuration is specifically optimized for which of the following operations?
(A) Heavy payload lifting and manipulation in vertical planes
(B) Continuous and spherical robotic workspace exploration
(C) Long-duration and continuous underwater locomotion
(D) High-speed assembly tasks in a horizontal plane

2024
8. Which robot anatomical classification naturally produces a cylindrical work envelope?
(A) Two prismatic and one rotary joint
(B) Articulated manipulator architecture
(C) Three independent prismatic joints
(D) One prismatic joint and two rotary joints

2002
9. In a spherical coordinate robot, the work volume geometry is primarily defined by which sequence of joints?
(A) Prismatic, Prismatic, Prismatic
(B) Rotary, Rotary, Prismatic
(C) Rotary, Prismatic, Prismatic
(D) Rotary, Rotary, Rotary

2009
10. How does the addition of a wrist assembly typically affect the overall function of an articulated manipulator?
(A) It increases the primary workspace volume significantly
(B) It dictates the orientation of the end-effector

planting hole
(B) Spot-spraying an individual stationary weed in a structured row
(C) Applying pesticide along a curved crop row
(D) Harvesting a highly localized, dense fruit cluster on a branch

2014

93. A path description in robotics fundamentally differs from a trajectory by lacking which explicit parameter?
(A) Position coordinates
(B) Orientation matrices
(C) Start and end boundaries
(D) Time dependence

2025

94. Trajectory generation in joint space involves interpolating between what variables?
(A) Cartesian X, Y, Z coordinates
(B) Euler pitch and yaw angles
(C) Initial and final joint angles directly
(D) Forces and torques acting on the end-effector

2005

95. Consider the following steps of Cartesian-space trajectory generation:
I. Interpolate Cartesian poses
II. Define initial and final Cartesian poses
III. Execute joint motions
IV. Apply inverse kinematics to interpolated points
Which of the following represents the correct chronological order of these steps?
(A) I, II, IV, III
(B) II, I, IV, III
(C) II, IV, I, III
(D) IV, II, I, III

2012

96. What is a primary disadvantage of Cartesian-space interpolation compared to joint-space interpolation?
(A) It cannot reliably produce perfectly straight-line end-effector motions
(B) It is completely impossible to specify dynamic target tool orientations
(C) It inherently avoids all potential kinematic boundary singularities
(D) It requires real-time inverse kinematics

2006

97. Which velocity profiling strategy avoids infinite acceleration spikes at the start and end of motion by utilizing a constant acceleration phase?
(A) Trapezoidal velocity profile
(B) Bang-bang profile
(C) Constant velocity profile
(D) Step-function velocity profile

2019

98. In a trapezoidal velocity profile, the motion sequence consists of which three distinct phases?
(A) Constant velocity, deceleration, and acceleration
(B) Instantaneous acceleration, zero velocity, and instantaneous deceleration
(C) Constant acceleration, constant velocity, and constant deceleration
(D) High acceleration, peak velocity, and low deceleration

2024

99. Why are higher-order polynomial trajectories (like 4-3-4) used instead of simple cubic polynomials for complex robot motions?
(A) They ensure multi-point smoothness
(B) They are computationally far less expensive to implement in real time
(C) They entirely eliminate the need for solving complex inverse kinematics
(D) They guarantee a completely linear geometric path in the joint space

2011

100. Match List I with List II.
List I: (Trajectory Term)
P. Path
Q. Trajectory
R. Via point
S. Spline
List II: (Definition)
1. Smooth mathematical curve connecting multiple points
2. Sequence of poses without time laws
3. Path augmented with timing laws
4. Intermediate pose the robot must pass through
(A) P-2, Q-3, R-4, S-1
(B) P-3, Q-2, R-1, S-4
(C) P-2, Q-1, R-4, S-3
(D) P-1, Q-3, R-2, S-4

2012

101. Proprioceptive sensors in robotics are primarily designed to measure what?
(A) The physical distance to a detected external obstacle
(B) Internal robot states like joint positions
(C) The surface color and quality of the crop being harvested

Click Here to Buy book on Amazon

(D) The ambient temperature of the surrounding field environment

2004

102. Which sensor is a common analog device used to measure absolute angular joint displacement?
(A) Incremental optical encoder
(B) Ultrasonic range finder
(C) Potentiometer
(D) Strain gauge

2021

103. An incremental optical encoder outputs two square waves (A and B channels) offset by 90 degrees. What vital information does this phase shift provide?
(A) The exact absolute position upon startup
(B) The total mechanical wear of the joint
(C) The temperature of the encoder disk
(D) The direction of rotation

2013

104. What is a key advantage of an absolute optical encoder over an incremental encoder?
(A) It retains position after a power cycle
(B) It is generally much cheaper and simpler to manufacture in high volume
(C) It requires significantly fewer internal code tracks on its optical disk
(D) It is completely immune to any ambient optical signal interference

2024

105. Velocity of a robotic joint can be measured directly using a tachometer, or it can be derived indirectly by doing what?
(A) Integrating linear acceleration sensor data over a given travel distance
(B) Differentiating encoder data over time
(C) Measuring the internal electrical coil resistance of the driving motors
(D) Calculating the multi-axis inverse kinematics of the current tool pose

2013

106. Exteroceptive sensors allow an agricultural robot to perform which crucial function?
(A) Monitor and log the internal system battery operating voltage
(B) Sense and adapt to unstructured field environments
(C) Determine the continuous rotational velocity of its own wheels
(D) Maintain and secure internal controller memory system integrity

2008

107. Which type of external sensor is best suited for detecting the exact moment a robot's end-effector comes into physical contact with a fragile fruit?
(A) Touch/Tactile sensor
(B) Laser range finder (LiDAR)
(C) Global Positioning System (GPS)
(D) Hall-effect rotary sensor

2024

108. Proximity sensors are commonly used in robotics to achieve what objective?
(A) Measure and log absolute mechanical joint rotation angles
(B) Calculate and map global coordinate field positions
(C) Detect nearby objects prior to physical contact
(D) Weigh and record the harvested payload dynamically

NODIA

2017

109. A multi-axis force/torque sensor typically installed at the robot's wrist utilizes which fundamental sensing element to measure deflections?
(A) Optical encoders
(B) Potentiometers
(C) Ultrasonic transducers
(D) Strain gauges

2011

110. Which external sensor measures distance by calculating the time-of-flight of light pulses, generating dense 3D point clouds of an orchard?
(A) Sonar
(B) Stereo vision cameras
(C) LiDAR
(D) Inductive proximity switches

2007

111. Slip sensors on a robotic gripper primarily function to detect what condition?
(A) The mobile robot wheels slipping on wet, muddy agricultural soil surface
(B) A gripped object sliding in the end-effector
(C) The primary drive motor stalling under extremely heavy payload loads
(D) The structural degradation and wear of the internal gear teeth

2017

112. In robotic control electronics, what is the primary function of an H-bridge motor driver?
(A) To convert high-voltage AC input power directly into regulated DC power

(B) To step up the operational voltage for high-power external sensor systems
(C) To decode and process complex quadrature signals from optical encoder units
(D) To drive a DC motor in both directions

2007
113. Pulse-Width Modulation (PWM) is utilized in DC motor control to achieve which effect?
(A) Regulate motor average voltage and speed
(B) Reverse the electrical polarity of the DC power supply instantly
(C) Eliminate all electromagnetic noise and radio frequency interference
(D) Generate transient high-voltage spikes to overcome mechanical static friction

2024
114. If a PWM signal driving a robotic wheel has a duty cycle of 75% on a 12V supply, what is the approximate average voltage delivered to the motor?
(A) 3V
(B) 6V
(C) 9V
(D) 12V

2021
115. Given below are two statements: one is labelled as Assertion (A) and the other is labelled as Reason (R).
Assertion (A): Stall detection is critical in agricultural robots to prevent motor burnout when the mechanism gets jammed by debris.
Reason (R): A stalled DC motor draws its maximum stall current, which generates excessive heat if sustained.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2014
116. Which specific parameter is continuously monitored by the motor controller to actively detect an overload or stall condition?
(A) Motor housing color
(B) Capacitance of the H-bridge
(C) Ambient humidity
(D) Current draw (Amperage)

2017
117. What distinguishes a Digital Signal Processor (DSP) from a standard general-purpose microprocessor in robotic control?
(A) It consumes significantly more power than standard microprocessors
(B) It is optimized for rapid math calculations
(C) It cannot process complex high-speed external sensor input lines
(D) It relies exclusively on legacy analog operational amplifier circuits

2003
118. Why is a Real-Time Operating System (RTOS) preferred over a general-purpose operating system (like standard Windows) for dynamic robot control?
(A) It offers a highly advanced and user-friendly graphical user interface
(B) It supports much higher display screen and video playback resolutions
(C) It guarantees deterministic execution times
(D) It automatically writes and debugs the required control algorithms

2011
119. In the context of embedded systems for robotics, what does the term 'latency' refer to?
(A) The physical distance measured between the sensor and the central processor
(B) The maximum theoretical data velocity of the internal embedded network
(C) The maximum total duration the robot can operate on single battery power
(D) The delay between sensing and system response

2011
120. Select the correct sequence of signal flow in a typical closed-loop robotic embedded system.
(A) Sensor → ADC → Microprocessor → DAC → Actuator
(B) Microprocessor → Sensor → ADC → Actuator → DAC
(C) Actuator → DAC → Microprocessor → ADC → Sensor
(D) ADC → DAC → Sensor → Microprocessor → Actuator

2014
121. Micro-Electro-Mechanical Systems (MEMS) in modern robotics typically integrate which components on a single silicon substrate?
(A) Large-scale mechanical hydraulic fluid pumps and directional control valves
(B) Microscale mechanical and electrical

Downloaded from www.pdf.tube

(C) P-3, Q-1, R-2, S-4
(D) P-1, Q-4, R-3, S-2

2011

176. Which condition represents a major challenge for LiDAR sensors deployed in dusty agricultural environments?
(A) The emitter cannot function or transmit signals in dark conditions
(B) Direct sunlight causes the internal housing to overheat rapidly
(C) Airborne dust particles cause false reflections and noisy data clouds
(D) Settled dust permanently shifts the laser output's frequency spectrum

2019

177. An H-bridge circuit uses four switching elements (like MOSFETs). To drive a motor forward, how must the switches be operated?
(A) All four individual switches are commanded to close at the same time
(B) Diagonally opposite switches are closed while the remaining two are open
(C) Two switches on the identical vertical bridge arm are closed together
(D) Only a single switch in the entire bridge is kept in the closed state

2009

178. What catastrophic failure occurs if two switches on the same vertical side of an H-bridge are closed simultaneously?
(A) The motor experiences voltage doubling and spins at twice its rated speed
(B) The motor armature shifts phases and instantly reverses rotational direction
(C) The PWM switching frequency increases to twice the programmed base rate
(D) A short circuit occurs, causing destructive electrical shoot-through

2006

179. A microcontroller generates a PWM signal for a robotic servo. The standard control signal for hobby servos typically relies on varying which specific parameter?
(A) The exact duration of the positive pulse
(B) The amplitude of the peak voltage level
(C) The fundamental frequency of the signal
(D) The magnitude of the analog load current

2007

180. Select the correct sequence of computational steps in a digital closed-loop PID control cycle.
(A) Read error, Calculate output, Read sensor, Apply actuator signal
(B) Read sensor, Calculate error, Compute PID output, Apply actuator signal
(C) Apply actuator signal, Read sensor, Compute PID output, Calculate error
(D) Compute PID output, Apply actuator signal, Calculate error, Read sensor

NODIA

2018

181. In an embedded Real-Time Operating System (RTOS), what is the function of the "scheduler"?
(A) To assign processor time to active tasks based on priority
(B) To perform filesystem formatting on the main storage drive
(C) To compress digital video streams for network transmission
(D) To control the electrical voltage output sent to actuators

2012

182. Which mathematical operation forms the core computational bottleneck that Digital Signal Processors (DSPs) are heavily optimized to execute in a single clock cycle?
(A) Floating-point division
(B) Logarithmic scaling
(C) Boolean XOR
(D) Multiply-Accumulate (MAC)

2003

183. Micro-robotics involves systems where the characteristic dimensions are typically in which range?
(A) Meters to Decimeters
(B) Centimeters to Millimeters
(C) Millimeters to Micrometers
(D) Micrometers to Nanometers

2001

184. In MEMS technology, a cantilever beam is often used as a fundamental mechanical element for sensing. It deflects in response to what?
(A) Shifts in the local surface color spectrum
(B) Transitions within the digital logic code
(C) Applied acceleration or mechanical stress
(D) Alterations in quantum state entanglement

2004

185. Select the correct sequence of basic photolithographic steps in MEMS fabrication.
(A) Etch, Apply Photoresist, Expose to UV, Develop
(B) Expose to UV, Apply Photoresist, Develop, Etch
(C) Apply Photoresist, Expose to UV, Develop,

(A) Only static gravitational forces acting downward on the main chassis
(B) External magnetic attraction forces between the footpads and the floor
(C) Inertial and gravity forces summing to zero within the footprint
(D) Aerodynamic drag and wind resistance forces during high-speed travel

2024

131. Legged locomotion is often advantageous over wheeled locomotion in agricultural fields primarily due to which factor?
(A) Legged robots can negotiate highly uneven agricultural terrain
(B) Legged robots are inherently much faster when traveling on smooth paved surfaces
(C) Legged robots require significantly simpler and less intensive control algorithms
(D) Legged robots consume far less electrical power and total energy overall

2024

132. In machine vision hardware, a CCD sensor fundamentally operates by doing what?
(A) Generating continuous analog ultrasonic sound wave signals in the medium
(B) Emitting highly structured laser light beams to measure spatial distances
(C) Measuring and logging micro-variations in the ambient target temperature
(D) Converting incident photons into stored electrical charges

2016

133. What is a primary architectural difference between CCD and CMOS image sensors?
(A) CMOS sensors are completely incapable of capturing high-resolution color images
(B) CMOS sensors allow active pixel amplification and readout
(C) CCD sensors integrate complex signal amplifier circuits at every individual pixel
(D) CCD sensors are highly preferred for ultra-low power compact embedded systems

2013

134. Illumination techniques are critical in agricultural machine vision. Front illumination is typically used to enhance what?
(A) The sharp silhouette and physical boundary outline of a target leaf
(B) Internal structural defects located deep within a woody plant stem
(C) The surface texture, color, and topological details of a fruit
(D) Transparent physical characteristics of individual falling water droplets

2019

135. Consider the following statements regarding machine vision illumination:
I. Backlighting produces a high-contrast silhouette.
II. Structured light projects geometric patterns to infer 3D shapes.
III. Diffuse lighting is used to create strong, harsh shadows for edge detection.
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) I
(D) II and III

2014

136. In a machine vision system, what is the primary role of a frame grabber?
(A) To physically adjust lens focus and control camera aperture settings
(B) To compress high-definition raw images directly into a JPEG format
(C) To digitize analog video signals and store them in memory buffers
(D) To emit strobed illumination synchronized with camera shutter speed

2003

137. Analog-to-digital (A/D) conversion of an image transforms continuous voltage signals into what mathematical structure?
(A) A multidimensional vector of continuous Fourier coefficients
(B) A single scalar brightness value representing average luminance
(C) A homogeneous transformation matrix defining spatial coordinate frames
(D) A discrete two-dimensional array of digital pixel intensity values

2011

138. If an image is digitized at an 8-bit depth for a grayscale sensor, how many distinct gray levels can each pixel represent?
(A) 8
(B) 64
(C) 128
(D) 256

2003

139. Low-level image processing typically involves operations acting on what basis?

Click Here to Buy book on Flipkart

components
(C) Standard high-torque industrial DC electric motors and reduction gearboxes
(D) High-voltage step-up power distribution transformers and regulators

2022
122. Which fundamental physical principle heavily influences MEMS devices differently than macro-scale robotic systems?
(A) Gravitational attraction forces dominate over microscopic surface friction
(B) Surface forces dominate over gravity and inertia
(C) Electromagnetic fields and magnetic forces are entirely eliminated at scale
(D) Internal sliding friction becomes completely negligible in micro-systems

2016
123. Which fabrication technology, borrowed from the semiconductor industry, is primarily used to manufacture MEMS devices?
(A) Photolithography and etching
(B) Automatic submerged arc welding systems
(C) High-pressure metal die casting methods
(D) Multi-axis computerized CNC milling tools

2019
124. An under-actuated manipulator is defined mathematically by which characteristic?
(A) It possesses significantly more independent actuators than degrees of freedom
(B) It utilizes exclusively high-pressure pneumatic cylinder power transmission
(C) It has fewer actuators than degrees of freedom
(D) It operates completely without any closed-loop sensory feedback mechanisms

2009
125. Match List I with List II.
List I: (MEMS/Embedded Concept)
P. RTOS
Q. DSP
R. MEMS Accelerometer
S. Under-actuation
List II: (Application)
1. Fast matrix multiplication for kinematics
2. Deterministic task scheduling
3. Passive compliant joint in a micro-gripper
4. Inertial measurement for micro-drones
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-4, Q-3, R-2, S-1
(D) P-2, Q-4, R-1, S-3

2015
126. In locomotion kinematics for legged agricultural robots, what defines the static stability margin?
(A) The maximum continuous travel speed the mobile robotic base can achieve on level ground
(B) The total dead weight of the robot structure minus the maximum rated payload
(C) The shortest distance from projected COM to support boundary
(D) The absolute height of the robot's center of mass measured above the ground plane

2019
127. A quadruped robot is statically stable if its projected center of mass lies within which geometric boundary?
(A) A perfect geometrical circle drawn through all four supporting feet points
(B) The polygon formed by the feet in contact with the ground
(C) A straight linear line connecting the center of the two front feet points
(D) The overall physical boundary dimensions of the robot's main body chassis

2002
128. What happens to the support polygon of a statically stable hexapod robot when it lifts three alternating legs simultaneously (tripod gait)?
(A) It immediately collapses to become a simple straight line
(B) It forms a highly critical and dynamically unstable single point
(C) It completely shrinks to a zero value
(D) It forms a supportive geometric triangle

NODIA

2008
129. Dynamic stability criteria, such as the Zero Moment Point (ZMP), become strictly necessary under what conditions?
(A) When the projected COM exits the support polygon
(B) When the multi-legged robot is standing completely still on a flat surface
(C) When the robot structure operates exclusively inside a high-vacuum chamber
(D) When the mechanical robot utilizes continuous wheels instead of articulated legs

2014
130. The Zero Moment Point (ZMP) theory is based on evaluating which dynamic forces acting on the foot-ground interface?

(D) It corrects optical geometric distortion caused by wide-angle camera lenses

2017

148. Which factor most severely limits the frame rate of high-resolution machine vision systems in real-time robotic harvesting?
(A) The physical mass and optical weight of the camera lens assembly
(B) The speed of light traveling between the object and camera sensor
(C) The computational load of high-throughput pixel-level processing
(D) The physical latency limitations of obsolete analog sensing hardware

2007

149. Why do researchers often prefer the HSV (Hue, Saturation, Value) color space over standard RGB for outdoor agricultural machine vision?
(A) HSV isolates color from intensity, improving robustness to outdoor lighting changes
(B) HSV natively compresses image arrays to achieve significantly smaller file sizes
(C) HSV inherently requires fewer data bits per pixel to represent similar resolutions
(D) RGB cannot differentiate between bright green foliage and yellow fruits effectively

2010

150. A robotic vision system uses stereo cameras to calculate depth. The fundamental geometric principle utilized is known as what?
(A) Spherical harmonics
(B) Homogeneous matrix inversion
(C) Optical flow integration
(D) Epipolar triangulation

2013

151. In terms of robot anatomy, the "work envelope" represents the physical space characterized by what?
(A) The maximum physical boundary of the robot's structural base
(B) The total volume reachable by the robot's end-effector
(C) The safe operating distance reserved for human operators
(D) The physical volume of the internal electrical cabinet

2021

152. Which term mathematically defines the total number of independent movements a robotic structure can perform?
(A) Workspace volume
(B) Accuracy quotient
(C) Degrees of Freedom (DOF)
(D) Repeatability index

NODIA

2021

153. A standard 6-DOF industrial manipulator is fully capable of positioning an end-effector anywhere in its workspace with any specified orientation. What happens if a 7th degree of freedom is added?
(A) The arm's kinematic equations become completely unsolvable with standard numerical methods
(B) The physical volume of the reachable workspace increases beyond practical physical limits
(C) The control resolution of the distal joints degrades significantly to near zero values
(D) The arm becomes kinematically redundant, enabling multiple joint postures for a single pose

2019

154. What determines the theoretical minimum control resolution achievable by a robotic joint?
(A) The physical resolution of the feedback encoder and control hardware
(B) The maximum structural length of the manipulator's most distal link
(C) The ambient thermal conditions and operating temperature of the joints
(D) The numerical precision limit of the inverse kinematics solver algorithm

2019

155. Consider the following statements concerning hydraulic versus electrical actuators:
I. Hydraulic systems are less susceptible to electromagnetic interference.
II. Electrical systems are generally cleaner and better suited for food-grade agriculture.
III. Electrical systems provide higher holding force without active power than hydraulics.
IV. Hydraulic systems typically require a central pump and fluid reservoir.
V. Stepper motors are a type of hydraulic actuator.
Which of the above statements are correct?
(A) I, II and IV
(B) I, III and V
(C) II, III, IV and V
(D) I, II and III

2003

156. The dot product of two unit vectors forming the columns of an orthogonal rotation matrix yields what value?
(A) -1
(B) 0
(C) 1
(D) 90

2016

157. Which matrix representation avoids all representational singularities when modeling arbitrary 3D rotations?
(A) 4×4 Homogeneous transformation matrices
(B) Three-parameter Z-Y-Z Euler angles
(C) Three-parameter Roll-Pitch-Yaw angles
(D) 3×3 Skew-symmetric projection matrices

2022

158. If a translation vector $d = [2, -1, 5]^T$ is applied to a point initially at the origin, what are its new coordinates?
(A) $(2,1,5)$
(B) $(-2,1,-5)$
(C) $(2,-1,5)$
(D) $(0,0,0)$

2009

159. When establishing D-H parameters, if two adjacent joint axes are strictly parallel, which parameter is typically chosen arbitrarily to simplify calculations?
(A) Link length (a_i)
(B) Joint angle (θ_i)
(C) Link twist (α_i)
(D) Joint distance (d_i)

2016

160. Forward kinematics maps from joint space to Cartesian space. Mathematically, this mapping is generally:
(A) Non-unique and linear
(B) Unique and linear
(C) Unique and nonlinear
(D) Non-unique and nonlinear

2001

161. A robotic weed-removal system uses a Cartesian gantry. Why is the inverse kinematics computation for this configuration considered trivial?
(A) It demands complex trigonometric decoupling calculations
(B) The joint variables map directly to the X, Y, Z axes
(C) It depends on high-dimensional unit quaternion math
(D) It features highly redundant kinematic degrees of freedom

2013

162. For an articulated agricultural arm, multiple inverse kinematic solutions exist (e.g., elbow-up vs. elbow-down). How does the controller typically select the appropriate solution?
(A) By executing the kinematic algorithm with the highest numerical precision
(B) By choosing default hardcoded positions such as the elbow-up posture
(C) By employing random stochastic selection among all available trajectories
(D) By choosing the solution requiring the smallest joint displacements

2012

163. The velocity Jacobian matrix $J(q)$ provides a linear relationship between joint velocities $(\dot{q})$ and end-effector velocities (v). Which equation represents this relationship?
(A) $v = J(q)\,\dot{q}$
(B) $v = J(q) + \dot{q}$
(C) $\dot{q} = J(q)\,v$
(D) $v = \dot{q}J(q)^{-1}$

2018

164. In regions near a kinematic singularity, what problematic behavior is typically exhibited by the joint actuators during Cartesian trajectory execution?
(A) They lock completely and cease to execute any further motion commands
(B) They align configurations to minimize overall electrical power draw
(C) They require extremely high or theoretically infinite joint velocities
(D) They instantly reverse their motor shaft rotation directions randomly

2018

165. Given below are two statements, one labeled as Assertion (A) and the other labeled as Reason (R).
Assertion (A): The moment of inertia of a robotic link varies depending on the axis about which it is rotating.
Reason (R): Moment of inertia is a tensor property that depends on both the object's mass and the spatial distribution of that mass relative to the axis of rotation.
(A) Both A and R are true and R is the correct explanation of A.

Downloaded from www.pdf.tube

(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2005
166. Which term in the Lagrangian dynamic equations accounts for the forces generated by a mass moving in a rotating reference frame?
(A) Gravitational force
(B) Frictional force
(C) Spring restorative force
(D) Coriolis force

2007
167. Point-to-point (PTP) motion is generally optimized for which robotic metric over a complex path?
(A) Maintaining a perfectly linear Cartesian line
(B) Cycle time and speed between resting states
(C) Keeping the end-effector perfectly level
(D) Constant sensor data acquisition rate

2006
168. To ensure smooth mechanical motion, a trajectory generator must ensure continuity in position, velocity, and which other derivative?
(A) Jerk
(B) Snap
(C) Acceleration
(D) Torque

2002
169. What mathematical curve is widely used to smoothly interpolate between multiple via points without exceeding the polynomial degree limits of stability?
(A) Exponential decay curves
(B) Logarithmic spirals
(C) Fourier series expansions
(D) Cubic splines

2012
170. Consider the following statements regarding trajectory planning:
I. Continuous Path planning is critical for spray painting or welding.
II. Joint-space interpolation guarantees straight-line motion in Cartesian space.
III. Trapezoidal velocity profiles have periods of constant acceleration.
Which of the above statements is/are INCORRECT?
(A) II
(B) I and III
(C) I
(D) II and III

2009
171. In optical encoders, the term "quadrature" refers to the specific relationship between the output channels A and B. What is this relationship?
(A) They are identical in phase
(B) They are 90 electrical degrees out of phase
(C) They are 180 electrical degrees out of phase
(D) They are 360 electrical degrees out of phase

2007
172. A potentiometer provides an output signal that corresponds to joint position. What physical property is fundamentally varying to produce this signal?
(A) Optical transmittance
(B) Electrical resistance
(C) Magnetic field strength
(D) Capacitive reactance

2025
173. Hall-effect sensors are frequently used in modern robotic motors. What physical field do they detect to determine rotor position?
(A) Magnetic field
(B) Gravity
(C) Electric field
(D) Thermal radiation

2017
174. Tactile sensors constructed using piezoresistive arrays are highly useful in agricultural harvesting grippers to evaluate what property of a fruit?
(A) Internal soluble solids and sugar content
(B) External skin pigmentation and color variations
(C) Localized surface firmness and contact pressure
(D) Transpiration rate and stomatal conductance

2019
175. Match the sensor technologies in List I with their corresponding robotic applications in List II.
List I: (Sensor Technology)
P. LiDAR
Q. Optical Encoder
R. Piezoresistive array
S. CMOS camera
List II: (Robotic Application)
1. Tactile pressure mapping
2. Internal joint angle measurement
3. 3D orchard mapping and obstacle detection
4. Visual fruit recognition
(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-4, S-1

NODIA

(A) Abstract classification of whole objects within the scene
(B) Neighborhood operations to extract basic image features
(C) High-level semantic analysis for scene understanding
(D) Volumetric database matching of complex 3D model data

2002

140. Given below are two statements, one labeled as Assertion (A) and the other labeled as Reason (R).
Assertion (A): Edge detection algorithms like the Sobel operator utilize spatial convolution masks to calculate image gradients.
Reason (R): Edges in a digital image correspond mathematically to regions of rapid intensity transitions, which yield high spatial derivative values.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025

141. Median filtering in agricultural image processing is specifically effective for removing which type of degradation?
(A) Impulse or salt-and-pepper noise while preserving edges
(B) High-frequency Gaussian blur caused by relative motion
(C) Ambient color cast variations arising from direct sunlight
(D) Geometric barrel and pincushion lens distortion patterns

2013

142. High-level image processing systems in robotics focus primarily on what objective?
(A) Removing high-frequency noise and enhancing image contrast
(B) Converting standard multi-channel color images to grayscale
(C) Interpreting the scene structure to make automated decisions
(D) Computing the physical focal length and field of view limits

2009

143. Which technique is commonly utilized in mid-to-high level processing to separate an agricultural object (like an apple) from its background?
(A) Global histogram equalization of contrast
(B) High-pass spatial filtering for edges
(C) Geometric camera lens calibration
(D) Color or intensity-based thresholding

2024

144. Morphological operations, such as dilation and erosion, are most often applied to which type of images in machine vision?
(A) Uncompressed RAW images
(B) Continuous analog signals
(C) Binary images (thresholded)
(D) RGB floating-point images

2008

145. Consider the following statements regarding machine vision algorithms:
I. Low-pass filters are used for edge detection.
II. Histogram equalization improves global image contrast.
III. Template matching is a high-level recognition technique.
IV. Convolution is restricted to 1D arrays in robotics.
Which of the above statements are INCORRECT?
(A) I and IV
(B) II and III
(C) I, III and IV
(D) II, III and IV

2002

146. For a robot to successfully grasp a recognized fruit, machine vision processing must eventually yield which data?
(A) The total number of classified pixels comprising the fruit's image
(B) The frequency-domain Fourier transform of the fruit's outer surface
(C) The average red-green-blue (RGB) value of the localized background
(D) The spatial 3D coordinates and size relative to the robot base frame

2007

147. A "Bayer filter" on a digital camera sensor serves what essential function?
(A) It filters incoming light to allow single-chip sensors to resolve color
(B) It blocks infrared electromagnetic wavelengths from hitting the CCD array
(C) It filters out high-frequency spatial noise and digital imaging artifacts

Click Here to Buy book on Amazon

Etch
(D) Develop, Etch, Apply Photoresist, Expose to UV

2016
186. Which application is a practical use of under-actuated mechanisms in agricultural robotics?
(A) Passive adaptive grippers conforming to irregular fruit shapes
(B) Ultra-rigid multi-axis Cartesian gantry positioning systems
(C) Multi-echo long-range LiDAR sensor and telemetry instruments
(D) Real-time high-speed trajectory planning and optimization solver

2021
187. The support polygon of a bipedal robot standing on one foot is geometrically defined by what?
(A) The theoretical floor span or area between both of the feet
(B) The contact boundary of the single load-bearing foot on the floor
(C) The maximum spatial bounding box enclosing the entire robot body
(D) A single coordinate point located precisely at the physical heel

2025
188. In terms of locomotion kinematics, what defines a "gait" for a legged robot?
(A) The maximum velocity reached during a straight sprint
(B) The repeating pattern of leg movements used for walking
(C) The static resting posture when actuator power is cut
(D) The total work or energy consumed over a set distance

2012
189. Machine vision filtering techniques rely heavily on spatial convolution. A convolution mask consisting entirely of positive values (like 1/9) acts as what kind of filter?
(A) Low-pass (smoothing/blurring)
(B) High-pass (edge detection)
(C) Band-pass filter
(D) Morphological skeletonizer

2003
190. Consider the following statements regarding image sensors:
I. CMOS sensors consume more power than CCD sensors.
II. Frame grabbers were more critical for older analog cameras than modern digital USB cameras.
III. Bayer filters reconstruct full color by interpolating neighboring pixels.
Which of the above statements is/are INCORRECT?
(A) I
(B) I and II
(C) II and III
(D) III

2025
191. Canny edge detection is considered superior to simple Sobel operators primarily because it includes which additional steps?
(A) It transforms standard digital color pixel arrays into multispectral infrared channels
(B) It requires specialized field-programmable gate array hardware acceleration units
(C) It operates on binary spatial matrices representing pure black-and-white silhouettes
(D) It uses non-maximum suppression and hysteresis thresholding to refine target edges

2021
192. Global image thresholding assumes that the target objects and background exhibit which statistical property in the image histogram?
(A) A completely uniform distribution across all possible gray levels
(B) A singular sharp peak containing all relevant pixel intensity values
(C) A bimodal distribution with a clear separation point between peaks
(D) A uniform random white noise distribution across the entire spectrum

2015
193. The Hough Transform is a robust machine vision algorithm specifically designed to detect what features?
(A) Asymmetric disease lesions and irregular necrotic blotches on crop leaves
(B) Geometric shapes like lines and circles despite partial target occlusions
(C) The mean thermodynamic temperature and ambient heat profiles of the scene
(D) Highly localized sub-pixel chromatic changes and subtle color variations

2017
194. Why is back-illumination highly effective for robotic seedling inspection on a conveyor belt?
(A) It illuminates complex venation and surface color variations of leaves

NODIA

2006

254. When processing LiDAR point clouds, "segmentation" refers to which computational task?
(A) Projecting multi-dimensional 3D points down into a single 2D photograph
(B) Removing point cloud data located beyond a designated radial distance threshold
(C) Grouping points into distinct clusters representing individual physical objects
(D) Assigning artificial color values to point indexes based on thermal parameters

2021

255. Consider the following statements concerning MEMS technology:
I. MEMS relies heavily on silicon microfabrication.
II. Scaling laws make electrostatic forces more dominant than gravity at the micro-scale.
III. MEMS cannot be integrated with electronic circuitry.
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I

2009

256. A robotic tractor operating on a 20-degree side slope is at risk of tipping. From a static stability perspective, tipping occurs when what condition is met?
(A) The drive wheels begin to slip and rotate at significantly different velocities
(B) The projection of the gravity center falls outside the footprint wheelbase area
(C) The electrical battery charge level falls below fifty percent of rated limit
(D) The continuous forward driving speed of the vehicle exceeds five kilometers/hour

2018

257. An active illumination system utilizing structured light determines 3D object topology by analyzing what phenomenon?
(A) The temporal delay or time taken for emitted laser beams to return to receptor
(B) The local temperature rise and thermal emission shift on the target's surface
(C) The spectral wavelength shift and color variation of returned optical reflection
(D) Distortion of a known structured light pattern projected on the target surface

2005

258. Which machine vision morphological operation is utilized to close small holes inside a thresholded target object without significantly altering its outer boundary size?
(A) Closing
(B) Opening
(C) Erosion
(D) Skeletonization

2002

259. Identifying the exact physical coordinates of a weed using a camera image requires intrinsic and extrinsic calibration. Extrinsic parameters relate the camera to what?
(A) The focal length of the lens
(B) The specific pixel density of the sensor
(C) The global or robot base coordinate system
(D) The radial distortion of the lens glass

2025

260. A bipedal robot utilizes dynamic walking. During the single-support phase, which leg is in contact with the ground?
(A) Stance leg
(B) Swing leg
(C) Both legs
(D) Neither leg

2014

261. In DC motor modeling for robotic control, the back-electromotive force (back-EMF) is proportional to what parameter?
(A) The physical mass and weight of the motor
(B) The ambient temperature of the environment
(C) The static torque load applied on the rotor
(D) The rotational velocity of the motor shaft

2016

262. Which control methodology continuously computes an optimal control action over a future time horizon, making it highly effective for complex trajectory tracking in autonomous tractors?
(A) Standard Proportional Control (P)
(B) Model Predictive Control (MPC)
(C) Open-loop sequencing
(D) Bang-bang control

2011

263. When designing a fruit-harvesting end-effector, why is an under-actuated compliant mechanism preferred over a rigid, fully-actuated multi-fingered hand?
(A) It requires high computational bandwidth and advanced real-time solvers

Downloaded from www.pdf.tube

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

(B) The unit vectors of the rotated axes relative to the base
(C) The physical joint angles of all consecutive robotic links
(D) The dynamic joint torques applied by internal motor units

2017

205. Consider the following steps to define a complete rigid body pose in homogeneous coordinates:
I. Define the rotation matrix
II. Define the translation vector
III. Combine into a 4×4 matrix
IV. Append the bottom row $[0\,0\,0\,1]$
Which of the following represents the correct sequence of these steps?
(A) I, II, III, IV
(B) II, I, IV, III
(C) I, II, IV, III
(D) I, IV, II, III

2024

206. If D-H parameter θ_i is a variable, what type of joint does this explicitly define?
(A) Prismatic joint
(B) Spherical joint
(C) Revolute joint
(D) Universal joint

2003

207. A planar 2R manipulator has link lengths $L_1 = 5$ and $L_2 = 5$. What is the maximum reach (radial distance) of the end-effector from the base origin?
(A) 5
(B) 10
(C) 25
(D) 50

2016

208. When solving inverse kinematics analytically for a PUMA-style robot, the calculation of the first three joint angles is largely dependent on which parameter?
(A) The orientation of the tool center point
(B) The clamping force of the active gripper
(C) The spatial position of the wrist center
(D) The physical mass of the grasped payload

2011

209. The condition where a robot loses the ability to move its end-effector in a specific Cartesian direction corresponds to a zero value in which matrix property?
(A) Inverse of the homogeneous matrix
(B) Determinant of the Jacobian matrix
(C) Trace of the rotation matrix
(D) Derivative of the inertia tensor

NODIA

2007

210. Newton-Euler equations of motion are formulated recursively. The forward recursion propagates which physical quantities?
(A) External forces and moments
(B) Internal temperatures and pressures
(C) Drive motor electrical currents
(D) Link velocities and accelerations

2001

211. The Lagrangian L is a fundamental quantity in energy-based dynamics. How is it calculated?
(A) $L = \text{Kinetic Energy} - \text{Potential Energy}$
(B) $L = \text{Kinetic Energy} + \text{Potential Energy}$
(C) $L = \text{Potential Energy} - \text{Kinetic Energy}$
(D) $L = \dfrac{\text{Kinetic Energy}}{\text{Potential Energy}}$

2008

212. In trajectory generation, a "via point" is fundamentally defined as what?
(A) The final resting coordinate of the path
(B) The origin of the global reference frame
(C) An intermediate waypoint along the planned path
(D) The kinematic singularity zone to be avoided

2003

213. To generate a perfectly straight Cartesian line between two points using a 6-DOF articulated arm, the controller must utilize which technique?
(A) Cartesian-space interpolation with inverse kinematics
(B) Joint-space interpolation between the terminal poses
(C) Open-loop pressure control of pneumatic line systems
(D) Arithmetic addition of the joint transformation matrices

2003

214. The 4-3-4 polynomial trajectory profile is specifically designed to ensure continuity of acceleration across how many segments?
(A) One segment
(B) Two segments
(C) Three segments
(D) Four segments

2024

215. Which sensor is specifically designed to measure the angular velocity of a robotic joint directly, outputting a voltage proportional to the rotational speed?
(A) Incremental optical encoder

ANSWERS

1. (A) Its reprogrammability for diverse agricultural tasks
Industrial robots possess a high degree of reprogrammability, allowing them to switch between diverse agricultural tasks such as weeding, harvesting, and spraying. Unlike rigid hard automation designed for a single repetitive task, these programmable systems adapt to varying field requirements by updating software trajectories, executing complex multi-axis paths, and integrating different specialized end-effectors easily.

2. (C) Unimate
The Unimate robot is historically recognized as the first commercially successful industrial robot, introduced in the early nineteen-sixties. Developed by George Devol and Joseph Engelberger, this hydraulic manipulator revolutionized manufacturing by performing hazardous, repetitive tasks on a General Motors assembly line. It paved the way for modern industrial robotics across diverse heavy manufacturing sectors worldwide.

3. (A) Precision variable-rate technology
Precision variable-rate technology enables agricultural machinery to dynamically adjust the application of inputs based on real-time environmental data. This advanced approach integrates sensors, spatial coordinates, and microprocessors to simultaneously monitor plant health and deliver precise, localized chemical doses. It optimizes resource application, reduces chemical waste, improves efficiency, and minimizes negative environmental impacts on agricultural ecosystems.

4. (D) Adaptive control
Adaptive control describes a closed-loop system where a controller automatically adjusts its parameters in real time to handle changing environmental dynamics and external disturbances. In agricultural robotics, this technique enables autonomous machines to modify their operational behavior based on continuously updated field variables, soil conditions, and crop interactions. This guarantees optimal performance under highly unpredictable outdoor scenarios.

5. (B) Modern agricultural robots operate exclusively in highly structured environments
Agricultural environments are inherently complex, highly variable, and semi-structured or completely unstructured. Modern agricultural robots must navigate varying lighting, unpredictable weather, and diverse biological crop profiles, meaning they do not operate exclusively in highly structured settings. Advanced vision systems, real-time kinematics, and adaptive control algorithms allow these systems to successfully perceive and manipulate targets in unpredictable, natural fields.

6. (C) Three prismatic joints
A Cartesian robot configuration, often called a gantry robot, utilizes three prismatic joints oriented perpendicularly along the orthogonal linear coordinate axes. This structural arrangement allows the manipulator to move linearly in three dimensions representing the X, Y, and Z directions. This simple mechanical design provides high structural rigidity, straightforward kinematic control calculations, and highly uniform accuracy across its workspace.

7. (D) High-speed assembly tasks in a horizontal plane
The Selective Compliance Assembly Robot Arm configuration is uniquely designed with two parallel rotary joints that provide compliance in a horizontal plane while remaining highly rigid vertically. This specific mechanical characteristic makes it exceptionally optimized for rapid, high-speed pick-and-place and assembly tasks. It is widely employed in manufacturing plants and automated packing facilities for sorting delicate materials quickly.

8. (A) Two prismatic and one rotary joint
A cylindrical coordinate robot architecture comprises two prismatic joints and one rotary joint arranged systematically. The rotary joint controls the rotation around a main vertical axis, while the two prismatic axes determine the height and radial extension of the manipulator

Click Here to Buy book on Flipkart

segmentation
(D) Morphological structuring element-based dilation steps

2018
225. A robotic base traversing an uneven agricultural field requires orientation tracking to maintain balance. Which MEMS device provides this orientation data by measuring angular velocity?
(A) MEMS accelerometer
(B) MEMS gyroscope
(C) MEMS pressure sensor
(D) MEMS tactile array

2005
226. What fundamental advantage do MEMS sensors have over conventional macro-scale sensors in agricultural micro-drones?
(A) Complete immunity to strong electromagnetic fields and noise
(B) Tolerance to direct, high-voltage atmospheric discharges
(C) Direct processing of image signals in analog format domain
(D) Reduced footprint, minimal mass, and low power consumption

2011
227. The concept of "under-actuation" in robotic hands implies that the grasping mechanism adapts to objects using what principle?
(A) Mechanical compliance using passive rather than active joints
(B) Mathematically infinite positioning and kinematic joint accuracy
(C) Closed-loop hydraulic force and pressure feedback control loops
(D) Real-time finite element stress analysis during structural load

2003
228. Legged robot dynamic stability relies on the Zero Moment Point (ZMP). If the ZMP remains strictly within the support polygon, what is the robot's state?
(A) It is dynamically unstable and falling
(B) It is perfectly statically stable but cannot move
(C) It is dynamically stable and will not tip over
(D) It is hovering

2005
229. A quadruped robot executing a "crawl" gait lifts how many legs at any given moment to maintain maximum stability?
(A) 1
(B) 2
(C) 3
(D) 4

2007
230. In high-level machine vision processing, "template matching" involves doing what to locate a target object?
(A) Computing the global distribution of gray levels to normalize exposure
(B) Blurring the input image until only the largest object region remains
(C) Tuning the camera lens focus mechanics dynamically until details sharp
(D) Sliding a template sub-image across the target to find correlations

2022
231. The primary purpose of applying a Gaussian blur filter to an image before edge detection is to achieve what?
(A) Accentuate high-frequency chrominance and spatial color artifacts
(B) Reduce high-frequency noise that produces spurious edge features
(C) Increase the average brightness and illumination of the overall image
(D) Convert multi-channel RGB representation directly into grayscale maps

2017
232. To detect the circular shapes of oranges on a tree in a 2D image, which advanced vision algorithm is most computationally appropriate?
(A) 1D Fourier Transform
(B) Simple global thresholding
(C) Circular Hough Transform
(D) Histogram equalization

2003
233. For robotic weed control, machine vision must differentiate between crops and weeds. If they are structurally similar, what advanced sensory technique is often employed?
(A) High-frequency active sonar depth profiling
(B) Physical tactile probe force measurement arrays
(C) High-voltage electrostatic capacitance sensing
(D) Multi-spectral imaging to analyze reflectance

2017
234. In the context of robotic actuation, "backlash" refers to which mechanical reality?
(A) Mechanical play between gear teeth causing errors on reversal

Downloaded from www.pdf.tube

(B) Electrical delay of transistors switching inside an H-bridge
(C) Thermal expansion and pressure changes of system hydraulic fluid
(D) Calculation latency of high-dimensional inverse kinematic solvers

2013
235. Consider the following statements concerning the Jacobian matrix:
I. It relates joint velocities to Cartesian velocities.
II. It is always a square matrix regardless of degrees of freedom.
III. Singularities occur when its determinant approaches zero (for square Jacobians).
Which of the above statements is/are correct?
(A) I and II
(B) I and III
(C) II and III
(D) II

2014
236. The term "Cartesian space" in robotics is synonymous with which of the following?
(A) Joint space
(B) Operational space
(C) Actuator space
(D) Null space

2023
237. A SCARA robot is highly efficient for planar assembly but generally poorly suited for what task?
(A) Complex 3D spherical contour milling
(B) Pick-and-place operations on a flat belt
(C) Applying adhesive along a flat 2D path
(D) Moving fast in the horizontal plane

2023
238. If a robotic sensor operates using "time-of-flight", it fundamentally determines distance by measuring what?
(A) The relative intensity of the reflected electro-optical beam
(B) The harmonic phase shift of the returning continuous wave signal
(C) The flight time of an emitted light pulse reflecting back to sensor
(D) The apparent physical scale of targets projected on image planes

2016
239. Which sensor explicitly requires physical deformation of its internal structure to generate a measurement signal?
(A) Optical encoder
(B) CMOS camera
(C) Ultrasonic transducer
(D) Strain gauge

NODIA

2001
240. The Nyquist-Shannon sampling theorem implies that to accurately digitize an analog sensor signal, the sampling rate must be at least what?
(A) Half the highest frequency component of the signal
(B) Equal to the highest frequency component
(C) Twice the highest frequency component of the signal
(D) Ten times the average frequency

2003
241. A Digital-to-Analog Converter (DAC) is critical in robotic control loops for which specific task?
(A) Converting continuous sensor voltages into digital codes for processing
(B) Converting digital control commands to analog actuator control voltages
(C) Writing sequential raw digital video frames into active memory buffers
(D) Executing mathematical matrix operations for inverse Jacobian systems

2021
242. In a 2D image, an "edge" mathematically represents a region of what?
(A) Constant uniform intensity values
(B) Completely zero spatial gradients
(C) Maximum absolute peak brightness
(D) Abrupt local intensity changes

2025
243. When programming a robotic agricultural sprayer, why is a continuous path (CP) algorithm strictly required over point-to-point (PTP)?
(A) CP controls velocity along the path to ensure uniform spray coverage
(B) CP minimizes the total travel duration regardless of final path shape
(C) CP bypasses the technical requirement to compute inverse kinematics
(D) CP utilizes regenerative braking to reduce electrical power consumption

2013
244. A homogeneous transformation matrix can represent pure rotation by containing what components?
(A) An identity matrix for the rotation block and a non-zero translation vector
(B) All zero entries except the bottom row

(C) A 3×3 rotation matrix with a zero translation vector
(D) Only diagonal elements equaling 1

2025

245. Consider the following statements regarding kinematics:
I. Forward kinematics has a single unique solution.
II. Inverse kinematics often yields multiple solutions.
III. Euler angles do not suffer from any mathematical singularities.
IV. The D-H convention uses four parameters per link.
Which of the above statements is/are INCORRECT?
(A) I and II
(B) III
(C) II and IV
(D) I, III and IV

2021

246. What mathematical constraint defines a unit quaternion used for spatial rotations?
(A) Its four individual scalar components must sum directly to zero
(B) It must restrict all component variables strictly to integer values
(C) Its three-dimensional vector part is constrained to be entirely zero
(D) Its norm (the sum of squared components) must always equal one

2016

247. The kinetic energy of a generic multi-link manipulator depends on which two varying quantities?
(A) Joint positions and joint velocities
(B) Joint positions and joint velocities
(C) Potential energy and temperature
(D) Link mass and ambient gravity

2023

248. The potential energy of a typical industrial robot link is a function of what?
(A) The magnitude of the link's instantaneous linear and angular velocity
(B) The structural stiffness and elasticity parameters of joint materials
(C) The height of the link's center of mass relative to gravity reference
(D) The instantaneous electrical power wattage consumed by the joint motor

2015

249. Which characteristic defines an "absolute" optical encoder?
(A) It uses a single optical sensor track for basic pulse generation
(B) It completely loses all joint coordinate data on system power down
(C) It can only track rotational speed rather than absolute position
(D) It outputs a unique digital code for every discrete angular position

2010

250. An agricultural robot traversing rough terrain utilizes wheel odometry. What is a primary limitation of using odometry alone for field navigation?
(A) It accumulates unbounded drift errors from wheel slippage on loose soil
(B) It demands constant high-bandwidth wireless internet and cloud connections
(C) It is fundamentally unable to measure linear or angular speed velocities
(D) It is structurally constrained to function only along to linear path axes

2009

251. Which mathematical structure efficiently represents the rotational dynamics of a rigid body in 3D space?
(A) A scalar mass value
(B) A 3×3 moment of inertia tensor
(C) A 1D position vector
(D) A Fourier transform coefficient

2005

252. The fundamental difference between spatial resolution and control resolution is caused by what?
(A) The particular syntax and execution speed of the programming language compiled
(B) Mechanical inaccuracies like backlash and physical structural joint deflections
(C) The spectral characteristics and raw color configurations of captured images
(D) The capacity limit and speed performance of the internal dynamic memory buffer

2011

253. For real-time agricultural obstacle avoidance, which sensor provides the most robust depth data across varying sunlight conditions?
(A) LiDAR
(B) Standard RGB camera
(C) Infrared proximity sensor
(D) Ultrasonic sensor

Click Here to Buy book on Amazon

(B) It enhances spatial depth perception and stereoscopic camera triangulation
(C) It lowers operational temperature to prevent digital image sensor overheating
(D) It forms a distinct silhouette for simpler geometric and area profiling

2019

195. A morphological "opening" operation consists of which two basic operations in sequence?
(A) Dilation followed by Erosion
(B) Erosion followed by Dilation
(C) Subtraction followed by Addition
(D) Blurring followed by Sharpening

2019

196. The purpose of morphological "erosion" on a binary image of a leaf is generally to achieve what result?
(A) Expand foreground boundaries to fill internal voids and holes
(B) Modify individual white pixels to show red color information
(C) Shrink foreground boundaries and remove minor background noise
(D) Compute the exact spatial coordinate of the center of mass

2011

197. Which coordinate system is naturally created when two revolute joints are mounted with orthogonal, intersecting axes?
(A) Spherical coordinate system
(B) Cartesian coordinate system
(C) Cylindrical coordinate system
(D) Toroidal coordinate system

2024

198. An articulated robot uses 6 rotary joints. What is the fundamental shape of its primary work envelope, ignoring minor wrist complexities?
(A) A perfect geometrical cube shape
(B) A symmetric cylindrical envelope
(C) A thin flat planar rectangle zone
(D) An approximately spherical volume

2007

199. What term describes the smallest position increment that the robotic hardware and software can execute?
(A) Repeatability
(B) Control resolution
(C) Mechanical backlash
(D) Dynamic threshold

2001

200. Given below are two statements, one labeled as Assertion (A) and the other labeled as Reason (R).
Assertion (A): Forward kinematics of a parallel Delta robot is computationally much more complex than its inverse kinematics.
Reason (R): The closed-loop kinematic chains of parallel robots require solving systems of highly coupled non-linear equations to determine the end-effector position from joint angles.
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is not the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

NODIA

2007

201. Which performance metric evaluates how closely a robot can reach a specific calculated target coordinate in an ideal mathematical space?
(A) Spatial resolution
(B) Repeatability
(C) Operating velocity
(D) Accuracy

2004

202. Pneumatic artificial muscles (McKibben actuators) are attractive for agricultural robotics because they inherently mimic biological muscles in what way?
(A) They contract under pressure and provide compliance
(B) They operate on electric currents without fluid lines
(C) They exhibit immense, rigid mechanical holding forces
(D) They contain integrated high-resolution optical encoders

2012

203. Which rotational representation requires four parameters and avoids singularity issues like gimbal lock?
(A) Skew-symmetric matrices
(B) Unit Quaternions
(C) Denavit-Hartenberg parameters
(D) Z-X-Z Euler angles

2008

204. In a 3×3 rotation matrix, the three columns conceptually represent what physical property of the rotated frame?
(A) The coordinates of the translation vector origin points

(B) It exerts massive, rigid mechanical clamping forces to secure objects
(C) It adapts to fruit shapes without complex closed-loop force sensors
(D) It is constrained to operate solely using high-pressure pneumatic lines

2025
264. What fundamental mathematical principle is heavily utilized by Digital Signal Processors (DSPs) to rapidly filter noise from sensor signals?
(A) Geometric theorem proving
(B) Denavit-Hartenberg parameter extraction
(C) Euler angle rotation
(D) Fast Fourier Transform (FFT)

2004
265. Machine vision frame grabbers often use Direct Memory Access (DMA). What is the primary benefit of DMA?
(A) It transfers images directly to memory, reducing CPU processing load
(B) It automatically filters out and eliminates background noise patterns
(C) It increases the physical spatial resolution of the CCD sensor arrays
(D) It converts raw monochrome grayscale files into multi-channel color

2003
266. Which type of visual sensor is biologically inspired and only outputs data asynchronously when a change in lighting intensity occurs, drastically reducing data bandwidth for high-speed tracking?
(A) High-speed CCD sensor
(B) Event-based camera
(C) Standard CMOS sensor
(D) Thermal microbolometer

2003
267. In precision agriculture, calculating the Normalized Difference Vegetation Index (NDVI) requires a machine vision sensor sensitive to which two spectral bands?
(A) Ultraviolet and Blue
(B) Red and Near-Infrared (NIR)
(C) Green and Far-Infrared
(D) X-ray and Gamma-ray

2023
268. Which robotic anatomical classification is inherently the most mathematically complex regarding its forward kinematics solutions?
(A) Closed-loop parallel manipulator
(B) Cartesian gantry-type manipulator
(C) Planar SCARA-style manipulator
(D) Spherical coordinate manipulator

2009
269. The ability of an embedded RTOS to guarantee a response to an external sensor interrupt within a strictly defined maximum time limit is referred to as what?
(A) Soft real-time performance
(B) Asynchronous polling
(C) Determinism
(D) Maximum throughput capacity

2019
270. As an agricultural robotic arm moves, the configuration of the arm changes, altering the effective inertia seen by the joint motors. How does advanced dynamic control handle this?
(A) By ignoring physical parameter shifts and maintaining a constant joint power
(B) By utilizing open-loop control strategies powered by basic pneumatic drives
(C) By limiting the manipulator trajectory strictly to low-velocity movements
(D) By updating the inertia tensor and applying real-time computed torque control

****

Downloaded from www.pdf.tube

(B) DC tachogenerator
(C) Linear potentiometer
(D) Capacitive proximity sensor

2018
216. Which external sensor relies on the piezoelectric effect or strain gauges to map contact profiles across a two-dimensional grid?
(A) Laser Range Finder
(B) Incremental encoder
(C) Tactile array sensor
(D) Hall-effect sensor

2010
217. In automated fruit picking, slip sensors generally detect micro-vibrations or relative motion at the gripper surface using which core technology?
(A) High-speed micro-cameras embedded in the gripper
(B) Heavy gyroscopic stabilization wheels on the wrist
(C) Microfluidic chemical sensors detecting skin residue
(D) Piezoelectric transducers sensing micro-vibrations

2013
218. An embedded system in a field robot experiences a 'hard real-time' constraint when missing a computational deadline results in what?
(A) Catastrophic system failure or physical damage
(B) A minor reduction in real-time video display quality
(C) A brief delay in writing log data to flash storage
(D) An unexpected increase in overall power consumption

2022
219. Pulse-Width Modulation (PWM) primarily regulates the power output to a DC motor by switching the supply voltage on and off at high frequencies. The percentage of time the voltage is "on" is called what?
(A) Frequency cycle
(B) Duty cycle
(C) Amplitude ratio
(D) Peak period

2005
220. Match the control/vision terms in List I with their corresponding functions in List II.
List I: (Control/Vision Term)
P. H-Bridge
Q. PWM
R. Frame Grabber
S. CMOS Sensor
List II: (Function)
1. Motor direction reversal
2. Active pixel light capture
3. Analog video digitization
4. Variable average voltage delivery
(A) P-1, Q-4, R-3, S-2
(B) P-2, Q-3, R-1, S-4
(C) P-4, Q-1, R-2, S-3
(D) P-1, Q-2, R-4, S-3

2024
221. In machine vision, the spatial resolution of a digital image refers to what?
(A) The pixel count along the horizontal and vertical axes
(B) The total bit depth and gray levels resolved per pixel
(C) The physical diameter and length of the camera lens body
(D) The duration of light exposure allowed by shutter speed

2003
222. An image histogram graphically represents the distribution of what image property?
(A) The coordinate positions of high-gradient edge features
(B) The estimated focal depth values across the entire scene
(C) The distribution frequency of pixel intensity levels
(D) The bounding box and physical sizes of detected objects

NODIA

2013
223. Applying a simple threshold operation to a grayscale image fundamentally converts it into what format?
(A) An RGB color image
(B) An analog voltage signal
(C) A frequency domain spectrum
(D) A binary black-and-white image

2023
224. Which technique is most appropriate for a machine vision system needing to identify ripe red apples amid dense green foliage under varying sunlight?
(A) Global grayscale thresholding of intensity values
(B) Spatial edge detection using gradient-based Sobel filters
(C) HSV color space conversion and hue-based

arm. This combination naturally generates a three-dimensional cylindrical workspace, making it ideal for vertical stacking and rotary assembly operations.

9. (B) Rotary, Rotary, Prismatic
In a spherical coordinate robot, the work volume geometry is defined by two successive rotary joints followed by a single prismatic joint. The two revolute axes provide angular panning and tilting, while the linear prismatic axis allows for radial extension. This sequence maps a coordinate system matching the classical mathematical spherical coordinate representation.

10. (B) It dictates the orientation of the end-effector
In articulated robotic manipulators, the regional arm structure primarily determines the spatial position of the wrist center. Adding a multi-axis wrist assembly at the end of the kinematic chain dictates the specific angular orientation of the attached tool or end-effector. This functional separation simplifies kinematics calculations by decoupling the translational positioning problem from the rotational orienting problem.

11. (A) Gantry robot
A gantry robot, characterized by its elevated overhead bridge structure and Cartesian coordinate movement, provides outstanding structural rigidity and highly uniform load-bearing capacity. Because its linear axes are physically supported along their entire lengths by a rigid framework, it can easily handle extremely heavy payloads across wide rectangular workspaces with minimal structural deflection, outperforming alternative articulated arm configurations.

12. (C) Control resolution and mechanical link inaccuracy
Spatial resolution in a robotic manipulator is mathematically defined as the sum of control resolution and mechanical link inaccuracy. Control resolution represents the smallest increment of motion the controller can command, determined by the system memory and actuator electronics. Mechanical link inaccuracies represent physical deviations caused by gear backlash, structural deflection, thermal expansion, and manufacturing tolerances in the system.

13. (D) Repeatability
Repeatability describes the ability of a robotic manipulator to consistently return to a previously taught or commanded position over multiple successive attempts under identical operating conditions. Unlike absolute accuracy, which evaluates the deviation from a global theoretical coordinate, repeatability focuses on the statistical precision and clustering of physical points reached when executing the same path repeatedly.

14. (C) 1024
The number of discrete, addressable positions for a single joint rotation is determined by the binary resolution of its feedback encoder. A system driven by a ten-bit encoder possesses two to the power of ten discrete steps. This mathematical calculation yields exactly one thousand twenty-four distinct positions that the robotic controller can resolve and command over a full rotation.

15. (D) A is false but R is true.
Repeatability measures the variance or spread of positional errors around an achieved cluster, whereas accuracy measures the difference between that cluster's mean and the actual target coordinate. A robotic system can exhibit exceptionally high repeatability by returning to the exact same incorrect spot every single time while remaining highly inaccurate if there is a large systematic offset from the target.

16. (D) The physical range of motion of the specific joint
Control resolution in a robotic joint is determined by dividing the physical range of motion of the joint by the total number of discrete control steps. These steps are directly defined by the bit capacity of the control memory. Therefore, for a fixed bit depth, a larger joint range of motion results in a larger, less precise minimum increment.

17. (A) Thermal expansion of the robotic links
Thermal expansion of robotic links physically changes the mechanical dimensions of the manipulator over time, causing progressive drift from the absolute coordinate model. Because this error changes slowly and systematically with ambient temperature variations, it degrades the absolute accuracy of the robot. However, since the immediate spatial movements remain

Click Here to Buy book on Flipkart

36. (D) The transverse (lateral) axis
Pitch motion in vehicles, aircraft, and agricultural drones corresponds to an angular rotation about the transverse or lateral axis of the body coordinate frame. This motion tilts the front of the vehicle upward or downward relative to the horizon. It plays a critical role in controlling flight velocity and stability during automated field spraying and crop monitoring operations.

37. (B) Unit quaternions
Unit quaternions offer a highly robust mathematical representation of spatial orientations without suffering from representational singularities like gimbal lock. By utilizing a four-parameter hyperspherical representation, quaternions permit smooth interpolation of trajectories and highly efficient computation. This makes them ideal for path-planning algorithms in autonomous tractors navigating complex, uneven, and high-slope agricultural fields.

38. (C) 4×4
A standard homogeneous transformation matrix utilized in three-dimensional spatial kinematics has a dimension of four-by-four. It systematically integrates a three-by-three rotation submatrix, a three-by-one translation vector, and a bottom row of zeros and ones. This layout allows programmers to represent complex composite spatial transformations, including sequential rotation and translation, through simple linear matrix multiplication.

39. (D) The translation vector
In a standard four-by-four homogeneous transformation matrix, the top-right three-by-one submatrix represents the translation vector. This vector defines the linear spatial displacement of the origin of the mobile coordinate frame relative to the reference frame. Combining this linear displacement with the rotation submatrix enables complete tracking of a rigid body's position in three-dimensional space.

40. (C) 1
The bottom-right element located at position $(4,4)$ of a standard rigid-body homogeneous transformation matrix is always populated by a value of one. This constant acts as a scaling factor within the projective coordinate representation of spatial vectors. Maintaining this unit value preserves the structural linear properties of affine transformations during spatial rotations and translations.

41. (B) By taking the inverse of T_A^B
To transition coordinate systems in reverse, mapping frame B back to frame A, one must compute the mathematical inverse of the transformation matrix from A to B. For a four-by-four homogeneous matrix, this inversion process involves transposing the orthogonal rotation submatrix and recalculating the negated translation vector to ensure correct inverse mapping in 3D space.

42. (A) Post-multiplication (multiplying on the right of the existing transformation matrix)
When computing compound spatial transformations where each successive transformation is defined relative to the current, moving coordinate frame, the mathematical matrices must be combined using post-multiplication. This requires multiplying each new transformation matrix to the right of the existing chain, properly accumulating the localized rotational and translational shifts in sequence.

43. (A) $[x, y, z, 1]^T$
Homogeneous coordinates represent a standard three-dimensional vector by augmenting its components with an additional scaling factor, typically having a unit value of one for rigid body points. This maps the vector into projective space, resulting in a four-dimensional column vector. This representation allows translation transformations to be executed as linear matrix multiplications.

NODIA

44. (C) Matrix multiplication
To determine the position and orientation of a sensor relative to the robot's base, successive coordinate transformations must be combined. Since the sensor frame is known relative to the end-effector and the end-effector relative to the base, standard matrix multiplication of these sequential homogeneous transformation matrices yields the complete combined sensor pose relative to the base origin.

45. (A) II
When inverting a homogeneous transformation matrix, the translation vector is not invariant; it undergoes rotation by the transposed submatrix and negation. Conversely, the rotation submatrix

exactly equal to its transpose. This fundamental mathematical property ensures that multiplying the matrix by its transpose yields the identity matrix. This preserves the length of vectors and the angles between them during rotational transformations in space.

27. (C) 1
A valid three-by-three rotation matrix representing proper spatial rotations in three-dimensional Euclidean space must belong to the special orthogonal group. A key algebraic property of this group is that the determinant of the matrix is always exactly equal to one. This positive unit value ensures that the transformation preserves spatial scale, orientation, and right-handed coordinate systems.

28. (C) Negating the components of the vector
In spatial coordinate transformations, the inverse of a pure translation vector represents a displacement of equal magnitude in the exact opposite direction. Mathematically, this operation is achieved by simply negating each individual coordinate component of the original vector. This negation cancels the initial linear translation, returning the transformed reference frame back to its original origin position.

29. (D) Zeros in the third row except for a 1 in the (3,3) position
A fundamental rotation matrix describing a rotation of angle θ about the Z-axis leaves the coordinate values along the Z-axis unchanged. Mathematically, this requires the third row of the matrix to contain zeros in the first two positions and a value of one in the third column. This structure ensures the Z-coordinate remains constant during the rotation.

30. (C) $R_x(\alpha)\,R_y(\beta) \neq R_y(\beta)\,R_x(\alpha)$
Sequential rotations in three-dimensional space are mathematically non-commutative, meaning that the order in which distinct rotations are applied significantly affects the final orientation of the rigid body. Multiplying a rotation matrix about the X-axis by one about the Y-axis yields a completely different result than if the Y-axis rotation were performed first.

31. (B) 3
Describing the spatial orientation of a rigid body in three-dimensional space requires a minimum of three independent parameters. These three rotational degrees of freedom can be represented using various mathematical frameworks, such as Euler angles, or three-dimensional exponential coordinates. This minimum parameter set uniquely determines the angular attitude without redundant state definitions.

32. (D) Rotation about Z, then current Y, then current X
The standard Z-Y-X Euler angle convention describes sequential rotations performed about the mobile axes of a rotating frame. The sequence begins with a rotation about the initial Z-axis, followed by a rotation about the newly positioned current Y-axis, and concludes with a rotation about the final current X-axis, mapping the frame's moving orientation.

33. (A) Fixed reference frame axes
The Roll-Pitch-Yaw orientation convention describes a sequence of three successive rotations that are always performed about the axes of a fixed, stationary reference coordinate frame. Unlike Euler angles which rotate about moving axes, this formulation maintains constant coordinate axes. This makes it highly intuitive for representing the physical attitude of mobile vehicles and aircraft relative to earth.

34. (C) Two rotational axes align, resulting in the loss of one degree of freedom
Gimbal lock is a mechanical and mathematical singularity that occurs when two of the three rotational axes in a sequential coordinate system become collinear. This alignment causes the physical system to lose one rotational degree of freedom, restricting the manipulator from executing arbitrary three-dimensional rotations. This poses a major hazard in aerospace flight dynamics and robotics trajectory planning.

NODIA

35. (B) I and III
Roll-Pitch-Yaw angles represent a series of three independent rotations defined around the axes of a fixed reference frame, making the first statement true. Euler angles suffer from representational singularities like gimbal lock, which validates the third statement. Conversely, unit quaternions require four parameters rather than three, rendering the second statement mathematically incorrect.

performance feedback controllers and achieving precise trajectory tracking.

75. (A) P-2, Q-4, R-1, S-3
In robotic system modeling, kinematic singularities are identified by calculating when the determinant of the Jacobian matrix equals zero. Orientations are represented using orthogonal rotation matrices, while joint and Cartesian velocity mapping is governed by the Jacobian matrix. Finally, positional transformations are mathematically described using standard four-by-four homogeneous transformation matrices in space.

76. (C) The point where the link's mass is concentrated
The center of mass of a rigid robotic link is the unique spatial point where the entire mass of that link is mathematically assumed to be concentrated. Localizing forces at this point greatly simplifies dynamic equations by allowing gravity, inertia, and linear accelerations to be calculated as single point vector operations during recursive Newton-Euler dynamic modeling.

77. (B) 3×3
The moment of inertia tensor for a general three-dimensional rigid body is represented mathematically by a symmetric three-by-three matrix. The diagonal elements of this tensor represent the moments of inertia about the coordinate axes, while the off-diagonal elements represent the products of inertia. This matrix defines how the body resists angular acceleration about different spatial axes.

78. (C) The products of inertia
The off-diagonal elements of a rigid body's inertia tensor correspond to the products of inertia, which mathematically describe mass asymmetry and mass distribution relative to the coordinate planes. These values indicate the degree of dynamic coupling between different axes of rotation, revealing whether rotating about one axis will induce forces and moments along another.

79. (B) All products of inertia become zero
When a chosen coordinate system aligns perfectly with the principal axes of a rigid body, the mass distribution becomes completely symmetrical relative to the planes. Consequently, all products of inertia in the symmetric tensor become zero, leaving a diagonal matrix populated only by the principal moments of inertia. This simplification greatly streamlines the rotational dynamics equations of motion.

80. (D) Euler's equation of motion
The Newton-Euler formulation of robotic manipulator dynamics splits the physical analysis of moving links into translational and rotational components. The rotational dynamics of each rigid link are governed specifically by Euler's equation of motion. This vector equation relates the applied joint torques, the angular velocities, and the link's inertia tensor to describe how the arm rotates in space.

81. (A) It suits recursive numerical algorithms
A major computational advantage of the Newton-Euler formulation is its high suitability for recursive numerical algorithms, which scale linearly with the number of joint axes. This efficiency makes it far superior to analytical methods when calculating joint forces and torques in real time for highly complex, multi-axis robotic manipulators, enabling rapid, closed-loop trajectory adjustments during operation.

82. (C) Link velocities and accelerations
In the recursive Newton-Euler dynamic modeling framework, the forward iteration pass moves systematically from the stationary robot base to the end-effector. This phase computes the linear and angular velocities and accelerations of each sequential link. These kinematic parameters are essential inputs for the subsequent backward pass, which calculates the required joint torques and reaction forces.

83. (A) Forces and joint torques
The backward iteration in the recursive Newton-Euler method moves from the end-effector back to the stationary base of the robot. This step uses the velocities and accelerations computed in the forward pass to solve the balance of forces and joint torques acting on each link. It determines the precise actuator outputs required to drive the planned robot motion.

84. (D) Kinetic and Potential energy
The Lagrangian dynamic formulation of robotic manipulators is an energy-based, scalar approach that models systems using kinetic and potential energy. By calculating the difference between these two energy terms, engineers derive the

Downloaded from www.pdf.tube

is orthogonal, making its inverse its transpose, the bottom row remains constant, and pre-multiplying maps transformations relative to fixed axes. This makes the second statement incorrect.

46. (C) 4
The Denavit-Hartenberg kinematic convention systematically models serial robotic manipulators by assigning local coordinate frames to each link. This convention requires exactly four parameters per joint-link pair: link length, link twist, joint distance, and joint angle. These parameters fully describe the spatial transformation and relative orientation between successive coordinate systems along the robot.

47. (B) $Z_{\{i-1\}}$ and Z_i along the X_i axis
In the standard Denavit-Hartenberg convention, the link length is defined as the physical distance measured between the previous joint axis and the current joint axis. This distance is measured specifically along the common perpendicular line, which corresponds to the current local X -axis. This parameter physically accounts for the offset between successive joint axes.

48. (D) Joint distance (d_i)
In the Denavit-Hartenberg kinematic framework, a prismatic joint is characterized by a linear translation along the joint axis of motion. This variable displacement corresponds directly to the joint distance parameter, which measures the sliding movement along the local Z-axis. Unlike rotary joints where the joint angle varies, prismatic joints maintain constant angles while distance changes dynamically.

49. (A) $Z_{\{i-1\}}$
Under the strict coordinate assignment rules of the Denavit-Hartenberg convention, the local X -axis for link i must be established perpendicular to the previous joint's Z-axis. This perpendicular constraint, combined with intersecting the current Z-axis, ensures a unique and highly structured coordinate transformation chain that simplifies forward kinematics calculations for complex multi-link robotic arms.

50. (C) $Z_{\{i-1\}}$ and Z_i measured about the X_i axis
The link twist parameter in the Denavit-Hartenberg convention represents the skew angle between the previous joint Z-axis and the current joint Z-axis. This angular parameter is measured about the current local X-axis, which acts as the common perpendicular line. It defines the structural rotation required to align the successive joint axes in three-dimensional space.

51. (A) It standardizes the derivation of forward kinematics
The primary advantage of using the Denavit-Hartenberg convention is that it standardizes the mathematical derivation of forward kinematics for complex robotic arms. By establishing consistent, repeatable rules for coordinate frame assignment, it enables engineers to easily represent joint-link transformations as standardized matrices, simplifying software development, design, and simulation across different robotic systems.

NODIA

52. (D) Zero
When two consecutive joint axes intersect in three-dimensional space, there is no physical offset between them along their common perpendicular line. Under the Denavit-Hartenberg coordinate assignment rules, this intersection forces the link length parameter to equal zero. This simplification reduces the complexity of the resulting homogeneous transformation matrices and speeds up forward kinematics calculations.

53. (B) $Rot(Z)$, $Trans(Z)$, $Trans(X)$, $Rot(X)$
The standard Denavit-Hartenberg transformation matrix for a single link is derived from a specific sequence of coordinate operations. This sequence begins with a rotation about the local Z-axis and a translation along Z to align origins. Next, a translation along the X-axis and a rotation about X align the coordinate frames with the subsequent joint axis.

54. (C) The end-effector pose given the individual joint parameters
Forward kinematics is the systematic process of determining the final position and orientation of a robot's end-effector relative to its base frame. This calculation uses the known lengths of the physical links and the current angles or displacements of each joint. This process provides a unique, straightforward mathematical solution essential for mapping the manipulator's workspace.

55. (A) I, III and V
In a two-revolute planar manipulator, forward kinematics calculates the end-effector position

using trigonometric projection onto the X and Y axes, relying only on link lengths and joint angles. The total orientation of the tool is the direct sum of these joint angles. Because the motion is restricted to a flat plane, the workspace is planar rather than spherical.

56. (B) 3
A planar three-revolute robotic manipulator operating strictly within a two-dimensional flat plane possesses exactly three degrees of freedom. These correspond to two translational coordinate directions, representing linear movement along the X and Y axes, and one rotational parameter, which defines the angular orientation of the end-effector tool tip within that same plane.

57. (B) Cartesian gantry
A spatial three-prismatic joint configuration represents the classic Cartesian gantry robot architecture. This design utilizes three orthogonal linear sliding joints to position the robot's end-effector anywhere within a rectangular box-shaped workspace. The structural decoupling of the X, Y, and Z axes provides high mechanical rigidity and simplifies kinematic calculations during high-precision manipulation tasks.

58. (C) 6
Computing the forward kinematics of a standard six-revolute robotic arm requires modeling the transformation across each individual link. Applying the Denavit-Hartenberg convention involves computing the sequential matrix product of exactly six independent link transformation matrices. This continuous multiplication yields the final position and orientation of the end-effector relative to the stationary base frame.

59. (A) $L_1\cos(\theta_1) + L_2\cos(\theta_1 + \theta_2)$
In a two-revolute planar robotic manipulator, the horizontal position of the end-effector is calculated by projecting each link onto the X -axis. Trigonometrically, the first link projects using the cosine of its joint angle, while the second link projects using the cosine of the combined angles. Summing these terms yields the final coordinate.

60. (C) It involves solving non-linear joint equations
Inverse kinematics is mathematically more complex than forward kinematics because it requires solving systems of highly non-linear transcendental joint equations containing trigonometric functions. Unlike forward kinematics, which has a single unique solution, inverse kinematics can yield multiple geometric solutions, infinite solutions in redundant systems, or no real solution if the target lies outside the workspace.

61. (D) The individual transformation matrix elements
Algebraic methods for inverse kinematics isolate joint variables by manipulating the individual elements of the forward kinematic transformation matrix. By equating the symbolical link transformation product with the target position and orientation matrix, engineers can separate specific transcendental equations. This allows them to systematically solve for each joint parameter in a closed-form analytical manner.

62. (C) Standard planar systems or arms with intersecting wrist axes
Geometric methods for calculating inverse kinematics are highly effective for simpler planar systems or spatial robotic arms featuring three intersecting revolute joint axes. This geometric structure allows the spatial positioning problem to be decoupled from the orientation problem. By applying basic trigonometry and law of cosines, designers can quickly solve for joint parameters analytically.

63. (D) 8
An elbow-type industrial robotic manipulator, such as the classic PUMA arm, typically has exactly eight unique inverse kinematic solutions for reaching a general target pose in space. These solutions correspond to combinations of physical configurations, including shoulder-right or shoulder-left, elbow-up or elbow-down, and wrist-flipped or wrist-unflipped, allowing multiple paths to the target.

64. (D) The target point lies outside the reachable workspace
When an inverse kinematics algorithm fails to calculate any real number solutions, it indicates that the desired target coordinate lies outside the manipulator's physical reach. This physical limitation occurs because the required link extension exceeds the maximum reach of the robot, causing the underlying trigonometric and algebraic equations to yield complex or mathematically undefined results.

Click Here to Buy book on Amazon

65. (A) Both A and R are true and R is the correct explanation of A.
For a six-degree-of-freedom manipulator, a closed-form analytical inverse kinematics solution is guaranteed if three consecutive revolute joints intersect at a single point, satisfying Pieper's criteria. This intersection allows the kinematic equations to decouple into separate positioning and orientation subproblems. This decoupling simplifies the mathematics and makes real-time control feasible for industrial manipulators.

66. (C) Wrist center
Decoupling the inverse kinematics of a six-axis manipulator featuring a spherical wrist relies on finding the spatial coordinates of the wrist center. Since the three wrist axes intersect at this single point, its position is independent of the tool's orientation. The positioning problem is solved first for this wrist center, followed by calculating the orientation angles.

67. (A) Joint velocities to end-effector velocities
The Jacobian matrix of a robotic manipulator is a fundamental mathematical entity that relates the joint velocities to the linear and angular velocities of the end-effector. This time-varying matrix acts as a multi-dimensional derivative of the forward kinematics equations, enabling real-time velocity planning, singularity detection, and force mapping during dynamic robot control and coordination.

68. (D) 6×6
For a six-degree-of-freedom robotic arm, the complete spatial Jacobian matrix has a dimension of six-by-six. The six rows represent the three linear velocity components and the three angular velocity components of the end-effector. The six columns map the contribution of each individual joint's velocity to the overall Cartesian motion of the robot's tip.

69. (B) 0
A kinematic singularity occurs in a robotic manipulator when the determinant of its square Jacobian matrix becomes exactly equal to zero. In this state, the Jacobian loses its full rank, meaning its rows or columns are no longer linearly independent. This mathematical condition restricts the robot's ability to move in certain Cartesian directions.

70. (C) The manipulator loses one or more degrees of freedom
When a robotic manipulator reaches a kinematic singularity boundary, its physical structure loses one or more degrees of freedom in Cartesian space. In this state, it is mathematically impossible to generate end-effector velocity along the lost directions, regardless of the commanded joint speeds. Additionally, attempting inverse kinematics near these regions can trigger dangerously high joint speed commands.

71. (D) The Jacobian matrix equation
Acceleration analysis in velocity kinematics involves taking the time derivative of the fundamental Jacobian matrix equation. Since the Jacobian is itself dependent on time-varying joint positions, differentiating this velocity relation yields both joint acceleration terms and Coriolis/centrifugal acceleration components. This step is critical for developing dynamic control algorithms and mapping high-speed trajectories accurately.

72. (A) The lower 3 rows
In the standard partition of a six-by-six spatial Jacobian matrix, the lower three rows govern the angular velocity of the end-effector. These rows map the relationship between the individual joint speeds and the rotational velocity vector of the robot's tool. Conversely, the upper three rows relate the joint speeds to the linear translational velocity of the tool tip.

73. (B) The inverse Jacobian matrix
To maintain a constant Cartesian spraying speed along crop rows, an agricultural robot must continuously compute the required joint speeds. This task requires updating the inverse Jacobian matrix in real time to map the constant tool velocity back to varying joint velocities. This continuous calculation ensures smooth, uniform chemical application despite the complex kinematics of the arm.

74. (B) Generated link motion and accelerations
Rigid body dynamics focuses on the mathematical relationship between the forces and torques applied to a manipulator and its resulting physical motion and accelerations. By analyzing mass, inertia, and external loads, dynamic models predict how the robotic links accelerate over time, which is essential for designing high-

NODIA

consistent, it does not affect the system's short-term positioning repeatability.

18. (C) Soil conditions cause unpredictable base shifts
Unlike industrial manufacturing plants with highly rigid, level concrete foundations, agricultural fields present complex, loose, and uneven terrain. Uneven soil conditions, mud, and terrain slopes cause unpredictable shifts in the mobile robot's base. This requires outdoor manipulators to employ adaptive, sensor-driven kinematic models that dynamically compensate for base displacement errors to maintain end-effector positioning accuracy relative to target plants.

19. (A) The standard deviation of the positions
Precision in robotic positioning describes the consistency and clustering of the manipulator's actual stops around a central point. Mathematically, this consistency is quantified using the standard deviation of the achieved positions over multiple target trials. A lower standard deviation indicates highly tight clustering, signifying superior precision and exceptional repeatability, regardless of whether the target coordinate is accurately hit.

20. (D) Hydraulic actuators
Hydraulic actuators utilize high-pressure fluid power to generate immense physical force and torque within a highly compact and lightweight physical envelope. In heavy agricultural robotics, such as forestry harvesting and heavy trenching machinery, these actuators are selected over electric or pneumatic alternatives because they deliver unmatched power-to-weight ratios and high stiffness under extreme mechanical load conditions.

21. (B) Natural compliance and softness
Pneumatic actuation relies on the compressibility of pressurized air, which inherently provides natural mechanical compliance and softness during operation. For delicate agricultural applications like fruit-picking end-effectors, this compressibility acts as a natural cushion. This prevents mechanical damage or bruising to fragile biological crops when the gripper securely grasps and detaches the produce from its branch.

22. (C) Risk of high-pressure fluid leakage contaminating the crop
A critical disadvantage of standard hydraulic robotic actuators in agricultural applications is the persistent risk of high-pressure fluid leakage. Because hydraulic systems operate using pressurized petroleum-based oils, any seal failure or hose rupture can release contaminants directly onto the crops and soil. This compromises agricultural food safety standards, poses environmental hazards, and destroys delicate crops.

23. (D) Brushless DC servomotors
Modern high-precision robotic joints predominantly utilize brushless DC servomotors combined with closed-loop feedback systems. These motors provide outstanding torque-to-weight ratios, high operational efficiency, precise speed regulation, and excellent thermal performance. By eliminating physical brushes, they minimize mechanical friction and wear, offering long-term reliability and precise position control required for highly demanding robotic manipulation tasks.

24. (A) Operating speed
Pneumatic actuators are renowned for their rapid response times and high operating speeds, driven by the swift expansion of compressed air. This rapid transit capability makes them ideal for simple, high-cycle, point-to-point automation tasks. However, due to air compressibility, they exhibit low energy efficiency, limited force capacity, and poorer positional accuracy compared to electric or hydraulic actuators.

25. (A) P-2, Q-4, R-1, S-3
Different robotic actuators possess distinct operational characteristics suited for specific applications. Hydraulic systems offer high power-to-weight ratios for heavy lifting, while pneumatic systems provide natural compliance for soft gripping. Stepper motors are ideal for simple open-loop positioning without encoders, and brushless DC motors provide high efficiency and continuous rotation for precise closed-loop speed and position control.

26. (B) Its inverse must be equal to its mathematical transpose
In robotics kinematics and matrix algebra, a square matrix is mathematically classified as an orthogonal rotation matrix if its inverse is

Downloaded from www.pdf.tube

Lagrangian function. This function is then processed through the Euler-Lagrange equations to yield the complete closed-form dynamic equations of motion for the multi-axis robot.

85. (B) Calculate Kinetic Energy, Calculate Potential Energy, Form Lagrangian, Apply Euler-Lagrange equations
Deriving manipulator dynamics using the Lagrangian method follows a structured, energy-based sequence. First, the total kinetic energy of the links is calculated, followed by determining their cumulative potential energy. The Lagrangian function is then formed by subtracting potential energy from kinetic energy. Finally, applying the Euler-Lagrange differential equations yields the symbolic, closed-form equations of motion.

86. (C) Kinetic energy
In the standard formulation of the Lagrangian equation, the variable K represents the total kinetic energy of the physical system. This scalar quantity accounts for the energy of both the linear and rotational motions of all robotic links and their attached actuators. It plays a foundational role in defining system behavior under dynamic acceleration and movement.

87. (D) Inertia, Coriolis/centrifugal forces, and gravity
The closed-form dynamic equations derived from the Lagrangian formulation express the joint torques as a combined function of three key mechanical terms. These are the link inertia forces, the joint velocity-dependent Coriolis and centrifugal forces, and the gravity forces acting on the physical structure. This structured equation is critical for feedback linearization and trajectory control algorithms.

88. (A) Joint-velocity interactions
Coriolis forces in a robotic manipulator's dynamic model arise mathematically from joint-velocity interactions. When multiple joint axes rotate simultaneously, their combined velocity vectors generate coupling forces that act on the moving links. This dynamic effect is distinct from centrifugal forces, which depend only on the mathematical square of a single joint's velocity during movement.

89. (B) Forward dynamics
Dynamic simulation of a robotic system requires solving the forward dynamics problem. This mathematical process calculates the resulting joint accelerations and subsequent motions given the applied actuator torques and forces. By integrating these accelerations over time, simulation software predicts the robot's physical trajectory and behavior under varying load, friction, and gravity conditions in virtual testing.

90. (B) I and II
The Lagrangian formulation is an energy-based approach using scalar quantities, whereas the Newton-Euler formulation is a force-based approach using vector math. Both methodologies are mathematically valid and can be solved numerically or symbolically. Therefore, the first two statements are correct, while the third statement, claiming Newton-Euler equations cannot be solved numerically, is false.

91. (A) Reaching the final target destination
In point-to-point trajectory planning, the robot controller's primary concern is ensuring the manipulator successfully reaches the specified final target destination. The exact path taken by the end-effector between the starting and ending points is not constrained or controlled, allowing the joints to move along their most computationally efficient paths without tracking geometric coordinate lines.

92. (C) Applying pesticide along a curved crop row
Continuous path execution is mandatory for agricultural applications such as applying pesticide along a curved crop row. Unlike point-to-point tasks that only prioritize reaching a final target, spraying requires the robot to strictly follow a defined geometric trajectory in space at a specified speed. This ensures uniform chemical coverage and prevents damaging surrounding plants.

NODIA

93. (D) Time dependence
In robotics trajectory planning, a path is defined purely as a geometric sequence of spatial coordinates and orientations without any explicit time parameters. A trajectory, conversely, is formed by augmenting this path with specific timing laws, velocities, and accelerations. Therefore, time dependence is the key characteristic that distinguishes a trajectory from a basic geometric path.

94. (C) Initial and final joint angles directly
Trajectory generation in joint space involves interpolating directly between the initial and final joint angles of the manipulator. By planning the motion within the joint coordinate domain, the controller avoids the need for computationally intensive real-time inverse kinematics. This approach guarantees smooth actuator movements and easily accommodates physical joint velocity and acceleration limits.

95. (B) II, I, IV, III
Generating a Cartesian-space trajectory follows a logical sequence. First, the initial and final Cartesian poses are defined. Second, the controller interpolates between these poses to plan the spatial path. Third, inverse kinematics is applied to each interpolated point to find the corresponding joint values. Finally, the actuators execute these joint motions in real time.

96. (D) It requires real-time inverse kinematics
A major disadvantage of Cartesian-space trajectory interpolation is that it requires executing real-time inverse kinematics calculations at every controller update cycle. Because the path is planned in 3D coordinates, the system must continuously convert these spatial steps into joint angles, which is computationally expensive and risks triggering issues if the arm approaches a kinematic singularity.

97. (A) Trapezoidal velocity profile
A trapezoidal velocity profile prevents infinite acceleration spikes at the start and end of movement by incorporating a constant acceleration phase. Unlike step-function profiles that demand instant speed changes, this strategy ramps up velocity linearly, maintains a constant speed, and ramps down linearly. This protects the mechanical joints, reduces vibrations, and prolongs actuator operating life.

98. (C) Constant acceleration, constant velocity, and constant deceleration
The motion sequence of a standard trapezoidal velocity profile is divided into three distinct phases. First, the joint undergoes a constant acceleration phase to ramp up its speed. Second, it maintains a constant velocity phase for the bulk of the movement. Finally, it enters a constant deceleration phase to bring the mechanism smoothly to a complete stop.

99. (A) They ensure multi-point smoothness
Higher-order polynomial trajectories, such as four-three-four splines, are preferred over simple cubic polynomials for complex multi-point motions because they ensure superior smoothness across multiple sequential via points. These higher-degree equations allow the trajectory planner to continuous-match velocity and acceleration boundaries at intermediate points, preventing sudden mechanical jerks and ensuring stable, continuous tracking.

100. (A) P-2, Q-3, R-4, S-1
Trajectory planning terminology is highly specific. A path represents a sequence of spatial poses without timing laws, whereas a trajectory represents a path augmented with timing laws. A via point is an intermediate pose that the robot must pass through during motion, and a spline is a smooth mathematical curve used to connect multiple points seamlessly.

101. (B) Internal robot states like joint positions
Proprioceptive sensors in robotics are specifically designed to measure internal system states, including joint positions, motor velocities, and overall battery power levels. Unlike exteroceptive sensors that perceive external surroundings, these devices focus entirely on tracking the physical state and mechanical configuration of the robot itself, which is vital for maintaining stable, closed-loop feedback control.

102. (C) Potentiometer
A potentiometer is correct because it provides a continuous analog voltage proportional to the angular position of a rotating shaft, making it a simple and widely used sensor for measuring absolute joint displacement. Incremental optical encoders provide relative position, ultrasonic range finders measure distance, and strain gauges detect mechanical strain rather than angular position.

103. (D) The direction of rotation
The direction of rotation is correct because the A and B channels of an incremental optical encoder are in quadrature, with one signal leading or lagging the other by 90 degrees. The phase relationship indicates whether the shaft rotates clockwise or counterclockwise. Incremental encoders do not provide absolute position after startup or measure temperature or mechanical wear.

Click Here to Buy book on Flipkart

104. (A) It retains position after a power cycle
It retains position after a power cycle because an absolute encoder assigns a unique digital code to every shaft position. When power is restored, the encoder immediately reports the correct position without requiring a homing procedure. Incremental encoders lose position information after power loss, while the remaining options are not inherent advantages of absolute encoders.

105. (B) Differentiating encoder data over time
Differentiating encoder position data with respect to time is correct because velocity is mathematically the rate of change of position. Encoder pulses or angular position measurements are sampled over time to calculate joint speed accurately. Integrating acceleration estimates displacement rather than velocity, while the other options do not directly determine joint velocity.

106. (B) Sense and adapt to unstructured field environments
Sense and adapt to unstructured field environments is correct because exteroceptive sensors gather information from the robot's surroundings, including crops, obstacles, soil, and terrain. This enables autonomous navigation and decision-making in agricultural fields. Monitoring battery voltage and wheel speed are proprioceptive functions related to the robot's internal state rather than the external environment.

107. (A) Touch/Tactile sensor
A touch or tactile sensor is correct because it detects physical contact and the applied force when a robotic gripper touches delicate objects such as fruits. This allows controlled gripping without causing damage. LiDAR and GPS provide distance and position information, while Hall-effect sensors detect magnetic fields or rotational motion rather than physical contact.

108. (C) Detect nearby objects prior to physical contact
Detect nearby objects prior to physical contact is correct because proximity sensors identify the presence of objects within a specified range without requiring direct contact. They are widely used for obstacle avoidance, object detection, and positioning in robotic systems. They do not directly measure joint angles, global position, or payload weight.

109. (D) Strain gauges
Strain gauges are correct because multi-axis force and torque sensors measure minute elastic deformations in a specially designed mechanical structure. These strain changes are converted into electrical signals proportional to applied forces and moments. Optical encoders measure rotation, potentiometers measure displacement, and ultrasonic transducers measure distance rather than force.

110. (C) LiDAR
LiDAR is correct because it measures distance using the time-of-flight of laser pulses reflected from surrounding objects. By scanning multiple directions rapidly, it generates dense three-dimensional point clouds useful for orchard mapping, navigation, and obstacle detection. Sonar uses sound waves, stereo vision relies on image processing, and inductive sensors detect nearby metallic objects only.

111. (B) A gripped object sliding in the end-effector
A gripped object sliding in the end-effector is correct because slip sensors detect relative movement between the gripper surface and the object. The controller can then increase gripping force or adjust manipulation to prevent dropping fragile items. These sensors are not intended to monitor wheel slip, motor stalling, or gear wear.

112. (D) To drive a DC motor in both directions
To drive a DC motor in both directions is correct because an H-bridge changes the polarity of the voltage applied across the motor terminals, allowing forward and reverse rotation. It also supports braking and speed control through PWM. It does not function as a power supply, voltage booster, or encoder signal processor.

113. (A) Regulate motor average voltage and speed
Regulating motor average voltage and speed is correct because Pulse-Width Modulation (PWM) varies the duty cycle of a fixed-voltage signal, thereby changing the average voltage delivered to the motor. This provides efficient speed control with minimal power loss. PWM does not reverse polarity, eliminate all electrical noise, or generate high-voltage spikes.

114. (C) 9V
A 75% duty cycle on a 12 V supply produces an average voltage of approximately 9 V because the average output equals supply voltage multiplied

Downloaded from www.pdf.tube

172. (B) Electrical resistance
A potentiometer is a resistive transducer that measures angular or linear displacement. As the sensor shaft moves, a sliding contact changes position along a resistive track, altering the electrical resistance between the terminal connections. This change in resistance modifies the output voltage, providing a simple analog representation of joint position.

173. (A) Magnetic field
Hall-effect sensors detect magnetic fields by measuring the voltage difference generated across an electrical conductor in the presence of a magnetic field. In brushless motor systems, these sensors are placed near the rotor to track the position of permanent magnets, providing the controller with real-time feedback for electronic commutation.

174. (C) Localized surface firmness and contact pressure
Piezoresistive materials change their electrical resistance when subjected to mechanical strain or compressive force. By arranging these sensors in a grid, a robotic gripper can measure contact pressure profiles. This feedback allows agricultural harvesting robots to assess fruit firmness and apply appropriate grip forces, preventing mechanical damage to delicate produce.

175. (A) P-3, Q-2, R-1, S-4
Different sensors serve distinct roles in robotic systems. LiDAR measures time-of-flight to generate three-dimensional spatial maps, while optical encoders monitor rotary joints to measure internal angles. Piezoresistive arrays detect pressure distributions to map tactile forces, and CMOS camera sensors capture light intensities across pixel grids for visual classification, mapping the pairings accurately.

176. (C) Airborne dust particles cause false reflections and noisy data clouds
LiDAR sensors measure distance by emitting laser pulses and timing their reflection back to the detector. In dusty agricultural fields, suspended dust particles scatter these light pulses, generating false reflections and noise in the point cloud. This signal degradation can obscure actual obstacles and create false positive detections for navigation software.

177. (B) Diagonally opposite switches are closed while the remaining two are open
An H-bridge controls DC motor direction by routing current through the armature. To spin the motor in a specific direction, diagonally opposite switches are closed while the remaining pair remains open. This configuration establishes a path from the power source to ground, allowing current to flow in the desired direction.

178. (D) A short circuit occurs, causing destructive electrical shoot-through
Closing two switches on the same vertical leg of an H-bridge creates a direct path from the positive supply rail to ground. This condition, known as shoot-through, bypasses the motor winding entirely and results in a short circuit. The resulting current spike can cause thermal runaway and destroy the switching transistors.

179. (A) The exact duration of the positive pulse
Hobby servo motors are controlled using pulse-width modulation at a standard frequency, typically fifty hertz. The internal controller determines the target angular position by measuring the duration of the high voltage pulse, which usually ranges from one to two milliseconds. Modulating this pulse width defines the target output angle.

NODIA

180. (B) Read sensor, Calculate error, Compute PID output, Apply actuator signal
In a digital feedback loop, the microcontroller first reads the current joint state from the feedback sensor. It then subtracts this value from the target setpoint to calculate the current error. Using this error, it computes the proportional, integral, and derivative terms to generate the control signal, which is applied to the actuator.

181. (A) To assign processor time to active tasks based on priority
An RTOS scheduler manages CPU time allocation among competing software tasks. It utilizes deterministic scheduling algorithms, such as preemptive priority scheduling, to run critical tasks when triggered. This resource allocation ensures that time-sensitive operations, such as sensor polling and safety interrupts, meet their strict execution deadlines.

182. (D) Multiply-Accumulate (MAC)
Digital signal processing algorithms, such as filtering, convolution, and Fourier transforms,

124. (C) It has fewer actuators than degrees of freedom
It has fewer actuators than degrees of freedom is correct because an under-actuated manipulator intentionally uses fewer independent actuators than its total mechanical degrees of freedom. Passive joints or compliant mechanisms provide the remaining motion, enabling simpler, lighter, and more adaptable robotic grippers. The other options do not define under-actuation.

125. (A) P-2, Q-1, R-4, S-3
This matching is correct because an RTOS provides deterministic task scheduling, a DSP performs rapid mathematical operations for robotics, MEMS accelerometers measure inertial acceleration in micro-drones, and under-actuation enables passive compliant joints in micro-grippers. Each technology fulfills a distinct function in modern robotic and embedded system design.

126. (C) The shortest distance from projected COM to support boundary
The shortest distance from the projected center of mass (COM) to the support boundary is correct because the static stability margin quantifies how close the robot is to tipping. A larger margin indicates greater stability. It does not depend directly on robot speed, weight, or the height of the center of mass alone.

127. (B) The polygon formed by the feet in contact with the ground
The polygon formed by the feet in contact with the ground is correct because a legged robot remains statically stable when the vertical projection of its center of mass lies inside this support polygon. If the projection moves outside the polygon, the robot becomes unstable and may tip over. The other geometric boundaries are incorrect.

128. (D) It forms a supportive geometric triangle
It forms a supportive geometric triangle is correct because, during a tripod gait, three alternating legs remain on the ground while the other three swing forward. These three supporting legs create a stable triangular support polygon that maintains static stability throughout locomotion. The support region therefore does not collapse into a line or point.

129. (A) When the projected COM exits the support polygon
When the projected center of mass exits the support polygon is correct because static stability no longer applies, and dynamic effects become essential for maintaining balance. Zero Moment Point (ZMP) analysis evaluates inertial and gravitational forces during motion to ensure dynamic stability. Standing robots on level ground generally require only static stability analysis.

130. (C) Inertial and gravity forces summing to zero within the footprint
Inertial and gravity forces summing to zero within the footprint is correct because Zero Moment Point (ZMP) theory evaluates the combined effect of inertial and gravitational forces acting on the robot. Stable walking requires the resultant moment about the ground contact area to remain within the support region. Magnetic and aerodynamic forces are not fundamental to ZMP.

131. (A) Legged robots can negotiate highly uneven agricultural terrain
Legged robots can negotiate highly uneven agricultural terrain because they independently place each foot on stable ground, allowing movement across obstacles, furrows, rocks, and irregular field surfaces. Wheeled robots perform better on smooth terrain but have limited mobility in rough environments. Legged systems generally require more complex control and often consume more energy.

132. (D) Converting incident photons into stored electrical charges
Converting incident photons into stored electrical charges is correct because each pixel in a CCD image sensor absorbs incoming light and generates electrical charge proportional to the light intensity. These charge packets are transferred sequentially for image formation. CCD sensors neither emit laser beams nor detect temperature or ultrasonic signals.

133. (B) CMOS sensors allow active pixel amplification and readout
CMOS sensors are correct because each pixel typically contains its own amplifier and associated circuitry, enabling direct readout, lower power consumption, and faster operation. CCD sensors transfer accumulated charge across the chip

Click Here to Buy book on Amazon

152. (C) Degrees of Freedom (DOF)
Degrees of freedom represent the number of independent coordinate variables needed to fully specify the physical configuration of a mechanical system. For robotic manipulators, this count typically corresponds to the number of active, independently controlled joint actuators. To position and orient an end-effector arbitrarily in three-dimensional space, a minimum of six independent variables is required.

153. (D) The arm becomes kinematically redundant, enabling multiple joint postures for a single pose
Adding a seventh joint to a standard manipulator creates kinematic redundancy, meaning the system has more control variables than necessary to define a spatial pose. This redundancy allows the arm to alter its internal posture or joint configuration while maintaining the exact position and orientation of its tool, helping to avoid obstacles or joint limits.

154. (A) The physical resolution of the feedback encoder and control hardware
Control resolution is the smallest position increment a robotic joint can reliably execute and detect. This capacity is fundamentally limited by the feedback sensor resolution, such as the encoder CPR, and the precision of the control hardware. While mechanical errors reduce actual accuracy, the feedback system sets the baseline for the theoretical minimum control increment.

155. (A) I, II and IV
Hydraulic actuators are rugged and unaffected by electromagnetic noise, but require centralized pumps and fluid lines, introducing fluid leak risks. Electrical systems are cleaner and highly suited for food processing and agriculture, whereas stepper motors are purely electrical devices. Thus, the first, second, and fourth statements are correct, while the other assertions are false.

156. (B) 0
A three-dimensional rotation matrix is an orthogonal matrix whose columns represent the mutually perpendicular unit axes of the rotated coordinate frame relative to the reference frame. Because these coordinate axes are strictly orthogonal, the dot product of any two distinct columns must equal zero, reflecting their perpendicular geometric relationship in Euclidean space.

NODIA

157. (A) 4×4 Homogeneous transformation matrices
Three-parameter representations of three-dimensional rotation, such as Euler or Roll-Pitch-Yaw angles, suffer from mathematical singularities known as gimbal lock where degrees of freedom are lost. In contrast, four-by-four homogeneous transformation matrices embed full three-by-three orthogonal matrices to describe rotation smoothly, avoiding mathematical representation singularities across all spatial orientations.

158. (C) $(2, -1, 5)$
Spatial translation shifts coordinates by adding a displacement vector directly to the initial position vector. When the starting location is the coordinate origin, represented mathematically as zero for all coordinate axes, adding the translation components yields a final position that corresponds exactly to the elements of the applied translation vector.

159. (D) Joint distance (d_i)
In the Denavit-Hartenberg convention, parallel joint axes do not intersect, meaning there are infinite common normals between them. This allows the common normal axis to be located along any line perpendicular to both axes. Consequently, the joint distance parameter along the parallel axis can be chosen arbitrarily to simplify coordinate assignments.

160. (C) Unique and nonlinear
Forward kinematics computes the unique position and orientation of the end-effector given a specific set of joint angles. Because industrial manipulators consist of rotational links, the transformation equations heavily utilize trigonometric functions, making the mapping highly non-linear. Thus, the forward kinematic process yields a single, unique, non-linear solution for any valid joint configuration.

161. (B) The joint variables map directly to the X , Y , Z axes
A Cartesian gantry robot utilizes linear prismatic joints arranged along orthogonal axes. Because these motion axes align directly with standard coordinate axes, the joint variables map directly to target positions. This decoupled structure eliminates complex trigonometric equations, making inverse kinematic calculations trivial compared to articulated manipulators.

are vital for successful robotic missions in field conditions.

143. (D) Color or intensity-based thresholding
Separating specific target objects from their surrounding background is a critical mid-level segmentation task. Thresholding achieves this partition by comparing pixel values against predefined intensity or color limits, dividing the image into binary foreground and background regions. This approach is highly effective in agriculture, where color differences distinguish ripe fruits from leaves and branches.

144. (C) Binary images (thresholded)
Morphological image processing operations process spatial structures based on shape characteristics. These non-linear techniques apply a small structuring element across a target grid, evaluating intersection properties. While these operations can be extended to grayscale datasets, they are most commonly and effectively applied to binary images to refine shapes, connect disconnected elements, or remove small isolated noise pixels.

145. (A) I and IV
Low-pass filters suppress high frequencies, resulting in image smoothing rather than edge detection, which requires high-pass filtering. Furthermore, spatial convolution in machine vision is frequently applied in two dimensions to process two-dimensional image matrices. Because low-pass filters blur features and convolution is multidimensional, the first and fourth statements are inaccurate, while the other statements remain correct.

146. (D) The spatial 3D coordinates and size relative to the robot base frame
For physical interaction, the robot controller must transform visual features into concrete spatial information. Pixel measurements must be mapped into coordinate frames that the manipulator can use for path generation. Consequently, the vision system must output the three-dimensional position, orientation, and size of the target relative to the robot base to execute a successful grasp.

147. (A) It filters incoming light to allow single-chip sensors to resolve color
Standard digital sensors measure light intensity rather than color. A Bayer filter grid is placed over a single-chip sensor, arranging red, green, and blue spectral filters in a specific mosaic pattern. This arrangement permits individual pixels to capture distinct primary wavelengths, enabling color reconstruction algorithms to interpolate full color images from a single exposure.

148. (C) The computational load of high-throughput pixel-level processing
High-resolution sensors capture millions of pixels per frame, creating massive data streams. Processing this extensive information in real-time requires high computational bandwidth for filtering, segmentation, and feature extraction. The processing speed of these complex vision algorithms on embedded controllers forms the primary bottleneck that limits operational frame rates in automated outdoor robotic systems.

149. (A) HSV isolates color from intensity, improving robustness to outdoor lighting changes
Standard red, green, and blue representations are highly sensitive to illumination changes because brightness directly scales all three channels. In contrast, the alternative color representation isolates pure chromatic information in the hue channel while separating intensity into the value channel. This decoupling allows agricultural vision systems to perform robust segmentation regardless of changing natural outdoor lighting conditions.

150. (D) Epipolar triangulation
Stereo vision systems resolve distance by capturing images from two horizontally offset viewpoints. The distance of target points is determined by measuring spatial disparity between corresponding features in the left and right perspectives. This depth calculation relies on epipolar geometry and triangulation principles to map 2D image coordinates into 3D Cartesian coordinates.

151. (B) The total volume reachable by the robot's end-effector
The work envelope, or workspace, defines the complete three-dimensional region of space that a robot end-effector can physically access. This volume is determined by the physical link lengths, the kinematic configuration, and the geometric travel limits of each joint. Designing robotic systems requires defining this volume to ensure all agricultural targets are reachable.

Downloaded from www.pdf.tube

by the duty cycle. Thus, $12 \times 0.75 = 9\,V$. This principle enables efficient motor speed control without continuously varying the supply voltage.

115. (A) Both A and R are true and R is the correct explanation of A.
Both the assertion and reason are true, and the reason correctly explains the assertion. When a DC motor stalls, its back electromotive force falls nearly to zero, causing it to draw maximum current. Sustained high current generates excessive heat that can damage windings, making stall detection essential for protecting agricultural robotic actuators.

116. (D) Current draw (Amperage)
Current draw is correct because motor current increases sharply during overload or stall conditions as mechanical resistance rises and back EMF decreases. Motor controllers continuously monitor current to detect abnormal operating conditions and activate protective actions. Motor color, ambient humidity, and H-bridge capacitance are not reliable indicators of overload.

117. (B) It is optimized for rapid math calculations
It is optimized for rapid mathematical calculations because a Digital Signal Processor (DSP) contains specialized hardware for high-speed multiply-accumulate operations commonly used in robotics, control systems, and signal processing. These features enable efficient execution of filtering, matrix operations, and control algorithms. The remaining options do not accurately describe DSP characteristics.

118. (C) It guarantees deterministic execution times
It guarantees deterministic execution times because a Real-Time Operating System (RTOS) schedules tasks to meet strict timing deadlines required for robot control. Predictable response times are essential for sensor processing and actuator control. General-purpose operating systems prioritize overall performance and user interaction rather than guaranteed timing behavior.

119. (D) The delay between sensing and system response
The delay between sensing and system response is correct because latency represents the time taken for information to travel through sensing, computation, and actuation stages before producing an output. Low latency is essential for accurate and stable robotic control. It does not refer to communication distance, bandwidth, or battery operating duration.

120. (A) Sensor → ADC → Microprocessor → DAC → Actuator
This sequence is correct because analog sensor signals are first converted into digital form by an Analog-to-Digital Converter (ADC), processed by the microprocessor, converted back to analog if required through a Digital-to-Analog Converter (DAC), and finally used to drive the actuator. This forms the basic signal flow of a closed-loop embedded control system.

NODIA

121. (B) Microscale mechanical and electrical components
Microscale mechanical and electrical components is correct because Micro-Electro-Mechanical Systems (MEMS) integrate miniature sensors, actuators, electronic circuits, and mechanical structures onto a single silicon chip. This integration enables compact, low-power, and high-performance devices widely used in robotics and consumer electronics. The other options describe conventional macro-scale components.

122. (B) Surface forces dominate over gravity and inertia
Surface forces dominate over gravity and inertia because, at microscale dimensions, adhesive, electrostatic, capillary, and surface tension forces become much more significant than gravitational and inertial forces. These effects strongly influence MEMS device design and operation. Therefore, MEMS engineering differs fundamentally from conventional macro-scale mechanical systems.

123. (A) Photolithography and etching
Photolithography and etching are correct because MEMS devices are fabricated using semiconductor manufacturing techniques that create microscopic structures on silicon wafers with high precision. These processes enable production of sensors, actuators, and microstructures. Welding, die casting, and CNC machining are unsuitable for fabricating such miniature integrated devices.

162. (D) By choosing the solution requiring the smallest joint displacements
Articulated manipulators often have multiple joint configurations that reach the same Cartesian pose. To ensure smooth, efficient motion, control software evaluates these options and selects the trajectory that minimizes joint travel from the current position. This selection minimizes transit times, limits energy consumption, and reduces mechanical wear on joint actuators.

163. (A) $v = J(q)\,\dot{q}$
The manipulator Jacobian is a fundamental multidimensional derivative mapping joint space velocities to Cartesian velocities. Mathematically, multiplying this configuration-dependent matrix by the joint velocity vector yields the instantaneous linear and angular velocity of the end-effector. This linear mapping is expressed by the standard matrix multiplication of the Jacobian and the joint derivative vector.

164. (C) They require extremely high or theoretically infinite joint velocities
At a kinematic singularity, the manipulator loses one or more degrees of freedom in operational space, causing the Jacobian matrix to become non-invertible. Attempting to move the end-effector along a Cartesian trajectory near these configurations requires joint speeds that approach infinity, which can overload actuators, saturate controllers, and cause tracking errors.

165. (A) Both A and R are true and R is the correct explanation of A.
The moment of inertia represents rotational inertia, which depends on mass distribution relative to the axis of rotation. Because robotic links are non-symmetrical, rotating them about different axes changes the mass distribution relative to the pivot, altering the effective inertia. Thus, the tensor property directly explains why link inertia varies across different rotational axes.

166. (D) Coriolis force
Robotic dynamic equations account for inertial, gravitational, and velocity-dependent forces acting on links. The velocity-dependent terms include centrifugal forces and Coriolis forces. The Coriolis terms describe the dynamic coupling forces that arise when a mass moves within a rotating reference frame, creating non-linear joint interactions that controllers must compensate for.

167. (B) Cycle time and speed between resting states
Point-to-point motion transitions a manipulator from an initial pose to a target configuration without constraining the geometric path of the end-effector. The trajectory generator focuses on minimizing cycle times and maximizing joint velocities within hardware acceleration limits. This approach makes it ideal for high-speed pick-and-place tasks where path geometry between endpoints is not critical.

168. (C) Acceleration
Smooth trajectory execution requires continuous joint profiles to prevent mechanical vibration and actuator wear. A standard trajectory planner must maintain continuity in position, velocity, and acceleration. Abrupt changes in acceleration produce infinite jerk, which causes mechanical shock, vibrational oscillations, and path tracking errors in high-speed agricultural robotic manipulators.

169. (D) Cubic splines
Interpolating multiple spatial waypoints using a single high-degree polynomial can cause numerical instability and unwanted oscillations, known as Runge's phenomenon. To avoid this, path planners utilize low-degree piecewise polynomials, specifically cubic splines, to connect target points. This method ensures continuous position, velocity, and acceleration while maintaining stable trajectories.

170. (A) II
Joint-space interpolation interpolates joint angles independently over time. Because the forward kinematic mappings of articulated manipulators are non-linear, constant joint velocity adjustments produce curved paths rather than straight lines in Cartesian space. Thus, the second statement is incorrect, while the other statements describing continuous paths and trapezoidal velocity profiles are correct.

171. (B) They are 90 electrical degrees out of phase
Incremental optical encoders use two sensing tracks to generate square-wave pulse sequences as the shaft rotates. These signal channels, labeled A and B, are placed ninety electrical degrees out of phase. This quadrature phase shift allows the controller to determine the direction of rotation and increase measurement resolution through edge-detection techniques.

Click Here to Buy book on Flipkart

192. (C) A bimodal distribution with a clear separation point between peaks
Global thresholding relies on separating foreground targets from the background using a single intensity value. This approach assumes the image histogram displays a bimodal distribution with two distinct peaks, representing the target and background pixels. This separation allows the algorithm to place a threshold in the valley between the peaks to segment the image.

193. (B) Geometric shapes like lines and circles despite partial target occlusions
The Hough transform is an analytical feature extraction technique that maps image space points into a parameter voting space. This approach identifies geometric shapes, such as lines, circles, or ellipses, by identifying local maxima in the parameter accumulator. This voting scheme works reliably even under partial occlusions, noise, and missing data.

194. (D) It forms a distinct silhouette for simpler geometric and area profiling
Placing the light source behind the target creates a high-contrast silhouette against a bright background. This back-illumination setup eliminates shadows and surface reflections, simplifying image segmentation. In seedling inspection, this high contrast allows algorithms to quickly analyze geometric properties, such as leaf area and stem structure, for quality grading.

195. (B) Erosion followed by Dilation
In mathematical morphology, an opening is a compound operation defined as erosion followed by dilation using the same structuring element. This sequence eliminates small foreground details, isolates narrow connections, and removes noise spikes while successfully preserving the overall size and shape of larger target objects in binary images.

196. (C) Shrink foreground boundaries and remove minor background noise
Morphological erosion shrinks the boundaries of foreground objects in a binary image by stripping away layers of pixels. This operation removes small, isolated background noise particles and breaks thin connections between adjacent shapes. Consequently, it is useful for separating touching leaves or cleaning up stray pixels in segmented agricultural images.

197. (A) Spherical coordinate system
Mounting two revolute joints with orthogonal, intersecting axes allows the end-effector to rotate in both elevation and azimuth. This kinematic arrangement defines position coordinates on a spherical surface, where coordinate locations are specified by radial distance, polar angle, and azimuthal angle. This setup forms the basis of spherical wrist configurations in robotics.

198. (D) An approximately spherical volume
An articulated robot with six rotary joints features a kinematic structure that rotates about a primary base axis, with subsequent links moving in vertical arcs. This rotational freedom generates a reach envelope that extends outward in all directions. Consequently, the primary workspace resembles an approximately spherical volume, minus any inner dead zones.

NODIA

199. (B) Control resolution
Control resolution is the smallest motion increment a robotic controller can physically execute and detect. This capacity depends on the combination of digital controller bit depth, sensor encoder resolution, and actuator step sizes. It defines the physical limit of positioning inputs before considering mechanical issues like backlash and joint compliance.

200. (A) Both A and R are true and R is the correct explanation of A.
Parallel robots, such as Delta configurations, consist of closed kinematic loops. While determining individual joint angles from a known tip position is straightforward, mapping joint inputs to the end-effector coordinate requires solving highly coupled non-linear equations with multiple algebraic solutions. This loop structure makes the forward kinematics calculation much more complex than the inverse kinematics.

201. (D) Accuracy
Accuracy is a key performance metric that evaluates a robot's ability to reach a commanded target position in its workspace. It measures the physical deviation between the actual end-effector position and the mathematically calculated coordinates. This metric differs from repeatability, which measures how consistently a robot returns to a previously taught position.

rely heavily on sum-of-products calculations. To accelerate these operations, DSP architectures feature specialized hardware that executes a multiplication and an addition in a single clock cycle. This multiply-accumulate instruction optimizes the performance of real-time sensor processing and control systems.

183. (C) Millimeters to Micrometers
Micro-robotics operates at scales where traditional macro fabrication techniques are no longer effective. The characteristic dimensions of these miniature systems range from millimeters down to micrometers. At this scale, electrostatic, surface tension, and viscous forces dominate over gravitational and inertial forces, requiring specialized micro-electro-mechanical design and manufacturing methodologies.

184. (C) Applied acceleration or mechanical stress
A cantilever beam is a fundamental structural component in micro-electro-mechanical systems. External forces, such as acceleration, pressure, or mechanical stress, deflect the beam from its resting position. This physical deflection is measured using capacitive, piezoresistive, or optical methods, converting mechanical energy into electrical signals for sensor applications.

185. (C) Apply Photoresist, Expose to UV, Develop, Etch
Photolithography patterns micro-scale structures on silicon substrates. First, a light-sensitive polymer layer is applied to the wafer. Next, ultraviolet light is projected through a patterned mask, exposing the photoresist. After development, which removes either exposed or unexposed resist areas, the pattern is transferred to the substrate through chemical or physical etching.

186. (A) Passive adaptive grippers conforming to irregular fruit shapes
Under-actuated mechanisms use fewer control actuators than physical degrees of freedom, relying on passive elements like springs to distribute forces. In agricultural harvesting, this approach enables compliant fingers that adapt automatically to irregular fruit shapes. This passive adaptation ensures secure, gentle grasping without requiring high-bandwidth control systems.

187. (B) The contact boundary of the single load-bearing foot on the floor
The support polygon defines the contact region on the floor that ensures static stability. When a bipedal robot stands on one foot, the support polygon is defined by the contact area of that single load-bearing foot. To maintain static balance, the projection of the center of mass must lie within this boundary.

NODIA

188. (B) The repeating pattern of leg movements used for walking
A gait is a periodic, synchronized pattern of leg movements that propels a legged vehicle across terrain. It defines the sequence and timing of foot contacts, switching between stance and swing phases for each leg. This coordinated cycle enables legged systems to maintain balance and traverse uneven ground.

189. (A) Low-pass (smoothing/blurring)
A spatial convolution mask filled with positive fractions that sum to one acts as an averaging filter. By calculating the mean value of a local neighborhood, this operation attenuates high-frequency spatial transitions and preserves low frequencies. This process blurs sharp details and smooths out fine noise, serving as a low-pass filter.

190. (A) I
CMOS sensors are highly energy-efficient because they integrate active pixel electronics directly on the chip, reducing power consumption compared to CCD sensors. Frame grabbers are unnecessary for digital USB cameras that output packetized data, and Bayer arrays require pixel interpolation to reconstruct full color images. Thus, only the first statement is incorrect.

191. (D) It uses non-maximum suppression and hysteresis thresholding to refine target edges
While basic gradient operators locate transitions, they yield thick boundaries and are sensitive to noise. The Canny edge detector improves on this by applying non-maximum suppression to thin edges to single-pixel widths. It then uses hysteresis thresholding with dual limits to link broken contours, providing refined and continuous edges.

to a common output amplifier. The remaining options incorrectly describe the capabilities and architecture of CMOS and CCD image sensors.

134. (C) The surface texture, color, and topological details of a fruit
The surface texture, color, and topological details of a fruit are correct because front illumination directly lights the object's visible surface, enhancing appearance, defects, texture, and color for inspection. Backlighting is mainly used for silhouette detection, while specialized illumination techniques are required for transparent objects or internal defect detection.

135. (A) I and II
Statements I and II are correct because backlighting produces high-contrast silhouettes that clearly define object boundaries, while structured light projects known patterns to reconstruct three-dimensional shapes accurately. Statement III is incorrect because diffuse lighting minimizes harsh shadows and glare, producing uniform illumination rather than enhancing strong shadow formation for edge detection.

136. (C) To digitize analog video signals and store them in memory buffers
A frame grabber serves as an essential interface in machine vision systems by receiving continuous analog video signals from cameras. It digitizes these incoming voltage streams into discrete pixels and stores them directly in computer memory buffers. This process enables high speed computer processors to access and analyze the digital image data for automated robotic operations.

137. (D) A discrete two-dimensional array of digital pixel intensity values
Analog-to-digital conversion in image processing samples continuous spatial coordinates and quantizes amplitude levels, converting the continuous voltage output of a sensor into a structured grid. This process yields a discrete two-dimensional matrix or array where each element represents the numerical brightness value of a specific pixel, allowing numerical algorithms to process the image.

138. (D) 256
The number of distinct intensity values in a digital image is determined by the bit depth of the digitization process. With an eight-bit representation, each pixel value is stored using eight binary digits, which yields two raised to the power of eight unique possibilities. This mathematical calculation results in exactly two hundred and fifty-six distinct grayscale levels.

139. (B) Neighborhood operations to extract basic image features
Low-level image processing focuses on primitive operations where both input and output are typically images. These tasks utilize local pixel operations and neighborhood configurations to perform functions such as noise reduction, contrast enhancement, and edge detection. These fundamental operations establish the essential structural features required for subsequent mid-level segmentation and high-level interpretation tasks in robotic vision.

140. (A) Both A and R are true and R is the correct explanation of A.
Edges are characterized by abrupt changes in pixel intensity, which mathematically correspond to local maxima in the first derivative of the image function. Operators like the Sobel filter approximate these spatial derivatives using small, weighted convolution matrices. Therefore, spatial gradients are directly calculated to identify rapid intensity transitions, proving both statements true and logically connected.

141. (A) Impulse or salt-and-pepper noise while preserving edges
Median filtering is a non-linear neighborhood operation that replaces the center pixel value with the statistical median of surrounding pixels. This approach is highly effective at removing impulse noise, commonly known as salt-and-pepper noise, which manifests as isolated bright or dark pixels. Crucially, this method removes outliers while successfully preserving sharp structural edges within the image.

142. (C) Interpreting the scene structure to make automated decisions
High-level image processing involves cognitive interpretation of visual scenes rather than simple pixel manipulation. It utilizes extracted features, recognized objects, and spatial relationships to understand environment context. This semantic knowledge enables autonomous systems to make critical decisions, such as path planning, obstacles avoidance, or target interaction, which

Downloaded from www.pdf.tube

202. (A) They contract under pressure and provide compliance
Pneumatic artificial muscles consist of an internal bladder surrounded by a braided fiber sleeve. When pressurized with air, the bladder expands radially and contracts axially, mimicking biological muscle contraction. The natural compressibility of air provides passive compliance, making these actuators ideal for gentle, adaptive food and fruit handling.

203. (B) Unit Quaternions
Unit quaternions represent three-dimensional rotations using a four-parameter complex number system. By using four coordinates restricted to a unit hypersphere, they provide a continuous representation of spatial orientation without mathematical singularities. This approach avoids gimbal lock, which often affects three-parameter Euler angle systems when joint axes align.

204. (B) The unit vectors of the rotated axes relative to the base
A three-by-three rotation matrix describes the orientation of a rotated coordinate frame relative to a reference frame. Each of the three columns represents a unit vector pointing along one of the rotated axes, projected onto the reference axes. Consequently, the column vectors define the direction cosines of the rotated coordinate system.

205. (A) I, II, III, IV
Defining a complete rigid-body pose in homogeneous coordinates requires constructing a single transformation matrix. First, the orientation is represented by a three-by-three rotation matrix, and position is defined by a three-by-one translation vector. These components are combined, and a bottom row of three zeros and a one is appended to complete the four-by-four matrix.

206. (C) Revolute joint
In the Denavit-Hartenberg convention, four link parameters define the relative position and orientation between adjacent coordinate frames. For a revolute joint, the link length, twist, and offset remain constant, while the joint angle serves as the control variable. Therefore, a varying θ parameter indicates a rotary joint in the kinematic chain.

207. (B) 10
The reach of a planar two-link manipulator is determined by its link lengths. The maximum radial distance from the base origin occurs when both revolute joints are fully extended, aligning the links in a straight line. Under this condition, the total reach is the sum of the individual link lengths, which equals ten units.

208. (C) The spatial position of the wrist center
Manipulators like the PUMA robot feature a spherical wrist, allowing kinematic decoupling. This design simplifies inverse kinematics by separating position and orientation calculations. The first three joints control the position of the wrist center, while the final three adjust orientation. Thus, calculating the first three joint variables depends on the spatial coordinates of the wrist center.

209. (B) Determinant of the Jacobian matrix
The velocity Jacobian relates joint rates to end-effector velocities. When a manipulator enters a singular configuration, it loses the ability to move in one or more Cartesian directions. Mathematically, this loss of mobility occurs when the Jacobian matrix becomes rank-deficient, which causes the determinant of a square Jacobian matrix to equal zero.

NODIA

210. (D) Link velocities and accelerations
The recursive Newton-Euler formulation calculates the joint torques required to produce a specific trajectory. The process begins with a forward recursion, starting from the fixed base and moving outward to the end-effector. This step propagates velocities and accelerations from link to link using the kinematic relationships defined by the robot geometry.

211. (A) $L =$ Kinetic Energy $-$ Potential Energy
Lagrangian mechanics models multi-body robot dynamics using energy properties. The Lagrangian function is defined as the difference between the total kinetic energy and the total potential energy of the system. Applying the Euler-Lagrange equations to this function generates the equations of motion, which relate joint torques to positions, velocities, and accelerations.

CHAPTER 11
Speech Processing

2022
1. Which of the following anatomical structures primarily acts as the acoustic source for voiced speech sounds in humans?
(A) Hard palate
(B) Alveolar ridge
(C) Velum
(D) Vocal cords

2001
2. In phonetic classification, which acoustic characteristic distinctly identifies unvoiced fricatives?
(A) Periodic low-frequency harmonic structure
(B) Sudden burst of energy following silence
(C) Aperiodic broadband noise source
(D) Distinct and stable formant frequencies

2011
3. In the source-filter theory of speech production, what does the fundamental frequency (pitch) primarily represent?
(A) The resonance of the nasal cavity
(B) The rate of vocal fold vibration
(C) The first formant frequency
(D) The length of the vocal tract

2009
4. Which psychoacoustic phenomenon describes the inability to hear a faint sound in the presence of a louder sound occurring simultaneously?
(A) Critical banding
(B) Pitch shifting
(C) Temporal integration
(D) Simultaneous masking

2002
5. To prevent aliasing during the digitization of a speech signal with a maximum frequency of 4 kHz, what is the minimum required sampling rate according to the Nyquist theorem?
(A) 2 kHz
(B) 4 kHz
(C) 8 kHz
(D) 16 kHz

2001
6. What is the primary advantage of using non-uniform quantization techniques, such as A-law or μ-law companding, in speech processing?
(A) They increase the dynamic range of the communication channel
(B) They eliminate the need for analog-to-digital conversion
(C) They maintain a constant signal-to-quantization noise ratio
(D) They linearly quantize high-amplitude signals with fine steps

2017
7. In Delta Modulation (DM), slope overload distortion occurs under which specific signal condition?
(A) When the input signal changes faster than the step size can track
(B) When the input signal amplitude remains strictly constant
(C) When the input signal changes slower than the step size can track
(D) When the sampling rate is exactly equal to the Nyquist rate

2012
8. How does Adaptive Differential Pulse Code Modulation (ADPCM) improve upon standard DPCM?
(A) By keeping the quantization step size strictly fixed across all signal segments
(B) By removing the predictor loop entirely from the internal encoder design
(C) By transmitting the analog residual signal directly over the physical channel
(D) By dynamically adapting the quantization step size based on signal variance

2004
9. In Code-Excited Linear Prediction (CELP) vocoders, what role does the codebook play?
(A) It stores predetermined filter coefficients representing the vocal tract
(B) It provides excitation vectors to model the residual signal
(C) It maps acoustic features directly onto

Click Here to Buy book on Amazon

222. (C) The distribution frequency of pixel intensity levels
An image histogram is a graphical plot that represents the distribution of pixel intensities within a digital image. The horizontal axis represents the range of possible gray levels, while the vertical axis shows the number of pixels at each intensity. This profile is useful for choosing threshold levels and analyzing overall image contrast.

223. (D) A binary black-and-white image
A threshold operation segment grayscale images by comparing each pixel intensity against a chosen reference value. Pixels with intensities equal to or greater than the threshold are set to one, while pixels below the value are set to zero. This mapping converts the grayscale image into a binary, black-and-white format.

224. (C) HSV color space conversion and hue-based segmentation
Spotting red fruits against green leaves under natural sunlight can be difficult because shadows and highlights alter standard RGB color values. Converting the images to the HSV color space separates chromatic information from brightness. This separation allows the system to segment the fruit using the hue channel, providing stable detection despite changing illumination.

225. (B) MEMS gyroscope
To track orientation and maintain balance on uneven ground, a mobile robot must monitor its rotational movements. A MEMS gyroscope measures angular velocity around its sensitive axes by detecting Coriolis forces acting on internal vibrating elements. This real-time rate data is integrated to track orientation shifts, helping prevent rollover accidents.

226. (D) Reduced footprint, minimal mass, and low power consumption
Micro-drones require lightweight, energy-efficient components to maximize battery life and flight times. MEMS sensors integrate miniature mechanical structures and electrical circuits on a single silicon chip. This fabrication approach provides a small physical footprint, minimal mass, and very low power draw, making these sensors ideal for compact aerial platforms.

227. (A) Mechanical compliance using passive rather than active joints
Under-actuation in robotic hands simplifies design by using fewer motors than the available degrees of freedom. The gripper relies on mechanical compliance, using passive elements like springs and linkages to distribute forces. This compliance allows the fingers to adapt naturally to irregular shapes without requiring complex control loops or multiple sensors.

228. (C) It is dynamically stable and will not tip over
The zero moment point is the position where the sum of horizontal inertial and gravitational forces equals zero. For legged robots, maintaining dynamic stability during motion requires keeping this point within the support polygon formed by active foot contacts. When this condition is met, the robot remains stable and will not tip over.

NODIA

229. (A) 1
The crawl gait is a statically stable walking pattern used by four-legged robots. To maintain stability, the robot lifts only one leg at a time while keeping the other three on the ground. This support tripod ensures the center of mass projection remains within the triangle, preventing the robot from falling.

230. (D) Sliding a template sub-image across the target to find correlations
Template matching is a feature detection method used to locate specific patterns in an image. The algorithm slides a small template image across the larger search image, calculating correlation values at each offset. High correlation scores identify matching regions, allowing the vision system to locate known target objects in the scene.

231. (B) Reduce high-frequency noise that produces spurious edge features
Edge detection algorithms calculate spatial derivatives to locate rapid changes in intensity. Because derivatives are highly sensitive to pixel-level variations, image noise can produce false edges. Applying a Gaussian blur filter smooths the image, reducing high-frequency noise and helping the edge detector focus on actual structural boundaries.

232. (C) Circular Hough Transform
The circular Hough transform is an analytical feature extraction technique designed to detect

circles in digital images. It maps edge points into a three-dimensional parameter space representing center coordinates and radii, voting on potential circles. This approach is highly effective for identifying spherical fruits like oranges, even with partial foliage occlusion.

233. (D) Multi-spectral imaging to analyze reflectance
When weeds and crops share similar shapes and sizes, standard color cameras may fail to distinguish between them. Multispectral imaging captures light across specific narrow bands, including near-infrared. Since different plant species display distinct spectral reflectance profiles, this spectral signature allows the vision system to identify and classify them accurately.

234. (A) Mechanical play between gear teeth causing errors on reversal
Backlash is the clearance or play between mating gear teeth in a drivetrain. When a joint actuator reverses its direction of rotation, this small gap causes a temporary delay before the output gear begins to move. This mechanical play introduces positional errors and instability in high-precision closed-loop control systems.

235. (B) I and III
The velocity Jacobian maps joint space rates to Cartesian speeds. For robots with unequal numbers of joints and Cartesian coordinates, the Jacobian matrix is non-square. However, for square Jacobians, kinematic singularities occur when the matrix determinant equals zero. Thus, the first and third statements are correct, while the second is false.

236. (B) Operational space
Cartesian space, often called operational or task space, defines the position and orientation of the end-effector using coordinates relative to a reference frame. This representation is distinct from joint space, which defines configurations using individual joint angles. Robotic command paths are typically planned in operational space to match physical tasks.

237. (A) Complex 3D spherical contour milling
A SCARA robot features a kinematic structure with parallel revolute joints, providing high rigidity and speed in the horizontal plane. While highly efficient for flat pick-and-place and planar assembly, this design lacks the orientation capabilities needed for complex spatial paths, making it poorly suited for three-dimensional spherical contour milling.

238. (C) The flight time of an emitted light pulse reflecting back to sensor
Time-of-flight sensors measure distance by emitting a light or sound pulse and timing its travel to a target and back to the receiver. Knowing the speed of the wave in the medium, the system calculates distance directly from this transit time. This principle is used in LiDAR and ultrasonic rangefinders.

239. (D) Strain gauge
A strain gauge measures mechanical strain by registering changes in electrical resistance. When bonded to a structure under load, the sensor deforms as the material stretches or compresses, altering the length and area of its internal conductive path. This physical deformation modifies resistance, producing an electrical signal proportional to the applied force.

240. (C) Twice the highest frequency component of the signal
The sampling theorem defines the conditions needed to digitize an analog signal without losing information. It states that the sampling frequency must be greater than twice the highest frequency component present in the analog signal. Sampling below this Nyquist rate causes aliasing, introducing artifacts that distort the digital signal representation.

241. (B) Converting digital control commands to analog actuator control voltages
Robotic microcontrollers compute control actions as digital numbers, but many physical actuators require continuous analog signals, such as variable voltage levels. A digital-to-analog converter bridges this gap by converting these digital outputs into proportional analog control voltages. This conversion allows the processor to drive analog motor amplifiers and control valves.

242. (D) Abrupt local intensity changes
In digital image processing, an edge represents a local boundary between regions with distinct properties. Mathematically, these boundaries correspond to areas of rapid intensity transitions. Edge detection algorithms identify these regions by calculating spatial derivatives, where local maxima in the gradient magnitude reveal the locations of abrupt intensity changes.

Downloaded from www.pdf.tube

243. (A) CP controls velocity along the path to ensure uniform spray coverage
Spraying operations require uniform chemical application, which depends on maintaining a steady speed along a specified trajectory. A continuous path algorithm controls both the trajectory geometry and the end-effector velocity throughout the motion. This control ensures consistent coverage, unlike point-to-point motion which only coordinates endpoint locations without path constraints.

244. (C) A 3×3 rotation matrix with a zero translation vector
A four-by-four homogeneous transformation matrix represents both position and orientation. To describe pure rotation, the upper-left three-by-three block contains the orthogonal rotation matrix, while the three-by-one translation column is set to zero. This setup represents a change in orientation without any spatial shift relative to the reference frame.

245. (B) III
Forward kinematics maps joint angles to a unique end-effector pose, while inverse kinematics often yields multiple joint configurations for a single spatial target. The Denavit-Hartenberg convention uses four link parameters. However, Euler angles suffer from mathematical singularities, such as gimbal lock. Thus, only the third statement is incorrect.

246. (D) Its norm (the sum of squared components) must always equal one
Unit quaternions represent spatial rotations using a four-dimensional vector of complex numbers. To represent orientation without scaling, these components must remain on a unit hypersphere. Mathematically, this condition requires the quaternion norm—the sum of the squared components—to always equal exactly one, preserving orientation properties during mathematical transformations.

247. (B) Joint positions and joint velocities
The kinetic energy of a multi-link manipulator depends on the velocity of its links and their mass distribution. Because the configuration of the robot changes as it moves, the effective inertia of the arm depends on the joint positions. Therefore, kinetic energy is a function of both joint positions and joint velocities.

NODIA

248. (C) The height of the link's center of mass relative to gravity reference
In robotic dynamics, the potential energy of a rigid link depends on gravitational forces. This energy is determined by the height of the link's center of mass relative to a chosen horizontal reference plane. Consequently, calculating potential energy requires tracking the vertical coordinates of the center of mass as joint configurations change.

249. (D) It outputs a unique digital code for every discrete angular position
An absolute optical encoder tracks position using a coded pattern on a rotating disc. This design allows the sensor to output a unique digital code for every discrete angular position. Because each angle has a unique code, the system retains its position data even after a power shutdown, eliminating homing cycles.

250. (A) It accumulates unbounded drift errors from wheel slippage on loose soil
Wheel odometry estimates robot position by integration of wheel rotations over time. In agricultural fields, loose soil and uneven terrain cause significant wheel slippage, where wheels rotate without moving the vehicle. Over time, these small errors accumulate, leading to unbounded positional drift that degrades navigation accuracy without external sensor correction.

251. (B) A 3×3 moment of inertia tensor
The rotational dynamics of a three-dimensional rigid body depend on how its mass is distributed relative to its center of rotation. A three-by-three moment of inertia tensor mathematically describes this spatial mass distribution across three orthogonal axes. This tensor allows engineers to calculate the torque required to produce rotational accelerations.

252. (B) Mechanical inaccuracies like backlash and physical structural joint deflections
Control resolution is the smallest motion step a robotic system can command and detect. However, the physical spatial resolution—the actual minimum displacement achieved—is affected by mechanical issues. Backlash in gears, friction, and structural deflections under load introduce tracking errors, creating a difference between commanded steps and actual physical motion.

212. (C) An intermediate waypoint along the planned path
A via point is an intermediate waypoint that a robot end-effector must pass through when moving between start and end positions. These points are used to shape the path, helping the robot avoid obstacles or navigate narrow passages without requiring the manipulator to come to a complete stop at each intermediate location.

213. (A) Cartesian-space interpolation with inverse kinematics
A straight line path requires the end-effector to follow a linear trajectory in Cartesian space. To achieve this, the controller interpolates intermediate poses along the spatial line and uses inverse kinematics at each step to compute the corresponding joint angles. This Cartesian-space planning ensures linear motion, unlike joint-space interpolation.

214. (C) Three segments
To interpolate a path with intermediate waypoints smoothly, the trajectory is divided into separate temporal intervals. A four-three-four polynomial profile uses a fourth-degree polynomial for the first segment, a third-degree polynomial for the middle segment, and a fourth-degree polynomial for the final segment. This structure ensures continuous acceleration across all three segments.

215. (B) DC tachogenerator
A DC tachogenerator is an analog transducer that measures rotational speed directly. It operates as a small generator, producing an output voltage that is directly proportional to the angular velocity of the shaft. This real-time analog velocity signal is highly useful for stabilizing velocity feedback loops in high-performance robotic actuator drives.

216. (C) Tactile array sensor
Tactile array sensors detect contact pressure distributions across a surface using a grid of sensing elements. These elements use piezoresistive, capacitive, or piezoelectric transduction to measure local forces. This grid array allows a robotic gripper to evaluate object shapes, identify contact locations, and adjust grip forces when handling delicate items.

217. (D) Piezoelectric transducers sensing micro-vibrations
Slip detection is crucial to prevent objects from sliding out of a robotic gripper. When an item begins to slip, it generates localized micro-vibrations at the contact interface. Integrated piezoelectric transducers detect these high-frequency vibrations, allowing the control system to quickly increase grasping force and prevent the target object from falling.

218. (A) Catastrophic system failure or physical damage
In hard real-time systems, the correctness of a computation depends on both its numerical result and the time it takes to deliver. Missing a deadline in this environment is a critical failure. For autonomous vehicles, failing to process obstacles or safety interrupts within the specified time can cause collisions, hardware damage, or system failure.

219. (B) Duty cycle
Pulse-width modulation regulates power delivery by switching the voltage source on and off at high frequencies. The duty cycle is the ratio of active pulse duration to the total signal period, expressed as a percentage. Adjusting this ratio alters the average voltage supplied to the motor, controlling its speed and torque.

220. (A) P-1, Q-4, R-3, S-2
Different electronic systems perform unique functions in robotic systems. An H-bridge switches current direction to reverse motors, while pulse-width modulation varies average voltage delivery to control speeds. Frame grabbers digitize analog video inputs, and CMOS sensors capture light at individual pixels, mapping these technologies to their respective operational roles.

221. (A) The pixel count along the horizontal and vertical axes
Spatial resolution defines the level of detail an image sensor can resolve, represented by the total number of pixels along the horizontal and vertical axes of the digital grid. Higher pixel counts allow the camera to capture finer structural features in the scene, which is essential for precise target classification and localization.

Click Here to Buy book on Flipkart

forces evenly. Under-actuated, compliant fingers adapt to object shapes through passive mechanical deflection. This design secures the fruit gently without requiring complex closed-loop control algorithms or arrays of force sensors, reducing system weight, cost, and control complexity.

264. (D) Fast Fourier Transform (FFT)
Filtering noise from raw sensor signals often requires shifting from the time domain to the frequency domain. The Fast Fourier Transform is an efficient algorithm that computes discrete Fourier transforms quickly. DSP hardware is optimized to run these calculations in real-time, allowing controllers to identify and filter out unwanted noise frequencies.

265. (A) It transfers images directly to memory, reducing CPU processing load
Capturing high-resolution video generates large streams of pixel data. Direct Memory Access allows the frame grabber to write this digitized image data directly to system RAM without involving the main CPU. By bypassing the processor during data transfers, DMA reduces CPU load, leaving processing resources free for image analysis algorithms.

266. (B) Event-based camera
Standard cameras capture complete frames at fixed intervals, producing high data redundancy. Event-based cameras are neuromorphic sensors where each pixel operates independently. Instead of capturing full frames, pixels output signals asynchronously only when they detect a change in local light intensity. This approach reduces data bandwidth, enabling high-speed tracking with minimal latency.

267. (B) Red and Near-Infrared (NIR)
The Normalized Difference Vegetation Index assesses plant health by measuring chlorophyll activity. Healthy vegetation absorbs red light for photosynthesis but reflects near-infrared light. By measuring reflectance in both the red and near-infrared bands, multispectral sensors allow systems to calculate this ratio, helping farmers monitor crop vigor and stress levels.

268. (A) Closed-loop parallel manipulator
While serial manipulators have straightforward forward kinematics and complex inverse kinematics, parallel configurations reverse this relationship. Parallel robots feature multiple closed kinematic loops connecting the base to the end-effector. Determining the end-effector pose from joint positions requires solving highly coupled, non-linear algebraic equations, making its forward kinematics solutions highly complex.

269. (C) Determinism
Embedded operating systems used in robotics must react to critical sensor events within strict timelines. This ability to guarantee a response within a defined maximum time limit is called determinism. This predictability ensures that safety stops, sensor interrupts, and actuator updates run reliably on time, which is essential for real-time safety.

270. (D) By updating the inertia tensor and applying real-time computed torque control
Moving joint links continuously alters the geometry and mass distribution of a manipulator, changing its effective inertia. Basic linear controllers may struggle with these changes at high speeds. Advanced dynamic controllers solve this by updating the inertia tensor in real-time and applying computed torque control to adjust joint effort, ensuring accurate trajectory tracking.

****

Downloaded from www.pdf.tube

(B) To estimate the prior probability of a sequence of words occurring
(C) To define the sequence of phonemes for each word in the vocabulary
(D) To normalize the dynamic range of the input speech signal

2025
20. Match the concepts in List I with their descriptions in List II:
List I: Concepts
P. Autocorrelation
Q. DTW
R. Spectrogram
S. Companding
List II: Descriptions
1. Non-linear alignment of two time series
2. Pitch detection and LPC analysis
3. Non-uniform quantization technique
4. Time-frequency representation
Which of the following is the correct matching?
(A) P-2, Q-1, R-4, S-3
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-1, R-3, S-4

2016
21. Which statistical model is typically used to represent the emission probabilities of acoustic states in an HMM-based speech recognizer?
(A) Gaussian Mixture Model (GMM)
(B) Linear Predictive Model
(C) Mel-scale Filter Bank
(D) Autoregressive Moving Average Model

2014
22. Which feature compensation technique is primarily designed to improve robust speech recognition by normalizing the mean of the features in noisy environments?
(A) Spectral subtraction noise estimation
(B) Dynamic time warping alignment
(C) Cepstral Mean Subtraction (CMS)
(D) Delta modulation delta-step coding

2015
23. In spectral subtraction algorithms for speech enhancement, the phenomenon known as "musical noise" is primarily caused by what?
(A) Residual noise peaks left after spectral subtraction
(B) Excessive overestimation of the additive noise phase spectrum
(C) The selection of an extremely short temporal windowing frame
(D) Frequency domain interference from adjacent critical bands

2005
24. Wiener filtering applied to speech enhancement seeks to minimize which specific metric?
(A) Absolute difference between noisy and clean phase spectra
(B) Perceptual masking threshold of the human auditory system
(C) Cross-correlation between the target speech and noise signals
(D) Mean Square Error of the estimated and clean speech signals

2024
25. Which signal processing technique is most appropriate for enhancing the harmonic structure of voiced speech while suppressing broadband noise?
(A) High-pass filtering
(B) Comb filtering
(C) Cepstral liftering
(D) Pre-emphasis filtering

NODIA

2010
26. Which anatomical structure functions as a dynamic valve to prevent air from entering the nasal cavity during the production of non-nasal sounds?
(A) Epiglottis structure
(B) Vocal glottis opening
(C) Velum (soft palate)
(D) Alveolar ridge bone

2025
27. Identify the phonetic classification for the phonemes /p/, /t/, and /k/.
(A) Voiced fricative consonants
(B) Nasal speech consonants
(C) Oral approximant sounds
(D) Unvoiced plosives (stops)

2025
28. In the source-filter model, the vocal tract filter is generally characterized mathematically by which type of system for vowel production?
(A) An all-pole IIR filter
(B) An all-zero FIR filter
(C) A non-linear dynamic system
(D) A high-pass differentiating filter

2004
29. Consider the following statements regarding the human auditory system:
I. The basilar membrane acts as a non-uniform

standard phonetic categories
(D) It eliminates the need for performing short-time Fourier analysis

2009

10. Given below are an Assertion (A) and a Reason (R):
Assertion (A): In short-time speech processing, a Hamming window is preferred over a rectangular window.
Reason (R): The Hamming window reduces spectral leakage by tapering the signal amplitude towards the boundaries, thereby reducing discontinuities.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

11. Which time-frequency resolution trade-off is inherent in the Short-Time Fourier Transform (STFT) of speech signals?
(A) A longer window provides better time resolution but poorer frequency resolution
(B) A shorter window provides better frequency resolution but poorer time resolution
(C) Window length has no effect on time or frequency resolution
(D) A longer window provides better frequency resolution but poorer time resolution

2022

12. In spectrographic analysis, what visual feature uniquely characterizes a wideband spectrogram compared to a narrowband spectrogram?
(A) Vertical striations indicating glottal pulses
(B) Clear visibility of individual harmonic lines
(C) Pronounced horizontal striations indicating pitch period
(D) High frequency resolution with poor time resolution

2010

13. Homomorphic signal processing separates the excitation source from the vocal tract filter by operating in which domain?
(A) Time domain
(B) Cepstral domain
(C) Frequency domain
(D) Autocorrelation domain

2010

14. Which step in the extraction of Mel-Frequency Cepstral Coefficients (MFCC) accounts for the non-linear human perception of frequency?
(A) Pre-emphasis high-pass filtering
(B) Mel-scale filter bank mapping
(C) Discrete Cosine Transform computation
(D) Fast Fourier Transform calculation

2006

15. The Linear Predictive Coding (LPC) model assumes that a speech sample can be approximated as a linear combination of what?
(A) Past speech samples
(B) Future speech samples
(C) Mel-frequency cepstral coefficients
(D) Gaussian mixture components

2023

16. In the Autocorrelation method for solving LPC equations, which characteristic ensures the stability of the all-pole filter?
(A) The signal is assumed to be deterministic and infinite
(B) The error is minimized over a strictly finite unwindowed interval
(C) The autocorrelation formulation of the windowed signal guarantees that all poles lie inside the unit circle
(D) The predictor order is always chosen to be infinite

2018

17. The Levinson-Durbin recursion is computationally efficient because it exploits which mathematical property of the autocorrelation matrix?
(A) Sparsity
(B) Orthogonality
(C) Non-stationarity
(D) Toeplitz symmetry

2001

18. When passing a speech signal through an LPC prediction error filter (inverse filter), the resulting output primarily resembles which component?
(A) The vocal tract resonance filter response
(B) The stationary background noise profile
(C) The excitation source residual signal
(D) The smoothed short-time spectral envelope

2015

19. In a standard Hidden Markov Model (HMM) based speech recognition system, what is the specific function of the language model?
(A) To evaluate the probability of a sequence of acoustic features given a phoneme

Click Here to Buy book on Amazon

253. (A) LiDAR
LiDAR sensors provide reliable distance measurements in outdoor environments by emitting their own laser light pulses. Because this active sensing system does not rely on ambient lighting, it is unaffected by shadows, solar glare, and changing sunlight. This independence makes LiDAR more robust than passive camera systems for real-time obstacle avoidance.

254. (C) Grouping points into distinct clusters representing individual physical objects
Processing raw LiDAR datasets requires grouping raw three-dimensional coordinate measurements into meaningful structures. Segmentation algorithms evaluate spatial relationships to cluster adjacent points that share similar geometric properties. This grouping partitions the unstructured point cloud into distinct spatial clusters, allowing subsequent algorithms to identify and classify individual obstacles or targets.

255. (A) I and II
MEMS devices are manufactured using silicon photolithography and etching techniques. At the micrometer scale, physical scaling laws alter the relative strength of forces; mass decreases with volume, making gravitational forces negligible while surface-area-dependent electrostatic forces become dominant. Because these systems are easily integrated with silicon circuitry, the third statement is incorrect.

256. (B) The projection of the gravity center falls outside the footprint wheelbase area
Static stability is determined by the relationship between a vehicle's center of gravity and its support base. On steep slopes, tilt angles shift the projection of the center of gravity. Tipping occurs when this downward vector falls outside the contact polygon defined by the wheel footprint, creating a rollover moment.

257. (D) Distortion of a known structured light pattern projected on the target surface
Structured light systems project a known geometric pattern, such as grids or stripes, onto a target surface. When this pattern hits a three-dimensional object, the surface topology deforms the pattern from its original shape. A camera captures this distortion, allowing triangulation algorithms to calculate surface depth and reconstruct 3D coordinates.

NODIA

258. (A) Closing
In mathematical morphology, closing is a compound operation consisting of dilation followed by erosion using a single structuring element. This sequence fills small gaps, plugs internal voids, and connects close boundaries within foreground objects. Crucially, this operation smooths target contours and fills internal holes without significantly expanding the original boundary.

259. (C) The global or robot base coordinate system
Camera calibration uses two sets of parameters to map 2D pixels to 3D space. While intrinsic parameters define internal properties like focal length and lens distortion, extrinsic parameters define the camera's pose. These parameters describe the rotation and translation that align the camera coordinate frame with the global or robot base coordinate frame.

260. (A) Stance leg
Bipedal locomotion alternate between single-support and double-support phases. During the single-support phase, one foot remains on the ground to support the robot's weight, while the other leg moves forward. The leg in contact with the floor is the stance leg, and the moving limb is called the swing leg.

261. (D) The rotational velocity of the motor shaft
When a DC motor rotates, the armature conductors cut through the magnetic field of the stator, generating an internal voltage that opposes the source voltage. This induced voltage, known as back-electromotive force, is directly proportional to the angular velocity of the rotor shaft, influencing the motor's speed and torque characteristics.

262. (B) Model Predictive Control (MPC)
Model predictive control is an advanced control strategy that uses a dynamic model of the system to predict future behavior. At each step, it solves an optimization problem to calculate control actions over a future time horizon. This approach handles multi-variable constraints, making it ideal for trajectory tracking in autonomous vehicles.

263. (C) It adapts to fruit shapes without complex closed-loop force sensors
Handling delicate, irregularly shaped produce requires grasping systems that distribute contact

filter bank.
II. High frequencies resonate near the apex of the cochlea.
III. Critical bands are wider at higher center frequencies.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2021
30. When continuous-time speech signal is sampled exactly at the Nyquist rate, what is the theoretical requirement for perfect reconstruction?
(A) An anti-aliasing high-pass filter system
(B) An ideal brick-wall low-pass filter
(C) A non-linear signal quantization block
(D) A high-frequency pre-emphasis filter

2024
31. Which of the following best defines granular noise in Delta Modulation?
(A) Noise occurring when the input signal is relatively constant
(B) Distortion introduced when the input signal changes too rapidly
(C) Auditory noise introduced by simultaneous frequency domain masking
(D) Processing artifacts resulting from short-time frame blocking

2006
32. What is the fundamental operational principle of Differential Pulse Code Modulation (DPCM)?
(A) Quantizing the absolute amplitude of each incoming speech sample
(B) Modulating the carrier frequency based on signal amplitude
(C) Quantizing the difference of current and predicted samples
(D) Encoding speech waveforms directly into cepstral coefficients

2019
33. In parametric vocoders, speech is reconstructed at the receiver using which primary components?
(A) Transmitted time-domain acoustic waveforms and detailed phase data
(B) Raw quantized speech sample sequences from uniform PCM coders
(C) Transmitted time-frequency spectrogram intensity distribution images
(D) Transmitted pitch, voicing status, and vocal tract parameters

2010
34. What is the primary purpose of applying a pre-emphasis filter prior to short-time speech processing?
(A) To effectively suppress undesirable high-frequency noise components
(B) To compress the overall dynamic range of the acoustic waveform
(C) To flatten the spectral envelope by boosting high frequencies
(D) To isolate and extract the signal's fundamental frequency

2006
35. Arrange the following steps of Short-Time Fourier Transform (STFT) processing in the correct sequential order:
I. Compute the Discrete Fourier Transform (DFT)
II. Multiply by a window function
III. Divide the signal into overlapping frames
IV. Compute the magnitude spectrum
Select the correct sequence:
(A) III, II, I, IV
(B) II, III, I, IV
(C) III, I, II, IV
(D) I, II, III, IV

2001
36. Which formant frequency in vowel production is most strongly influenced by the vertical position (height) of the tongue?
(A) Fundamental Frequency (F_0)
(B) First Formant (F_1)
(C) Second Formant (F_2)
(D) Third Formant (F_3)

2010
37. During complex cepstrum analysis, why is phase unwrapping a necessary mathematical step?
(A) To obtain a continuous phase curve for the complex logarithm
(B) To ensure that the resulting Fourier transform is strictly real
(C) To eliminate the fundamental pitch period from vocal tract response
(D) To perform non-linear critical band smoothing across frequencies

2001
38. The Discrete Cosine Transform (DCT) is applied in MFCC extraction primarily to achieve which outcome?
(A) To convert the signal back to the time domain
(B) To align the pitch epochs accurately

Downloaded from www.pdf.tube

(C) Glottal closure instants
(D) Background noise impulses

2025

113. Homomorphic signal processing can deconvolve the speech signal because convolution in the time domain becomes what operation in the complex cepstrum domain?
(A) Multiplication
(B) Subtraction
(C) Division
(D) Addition

2003

114. The log-energy output of the Mel-filter bank is transformed into MFCCs using the Discrete Cosine Transform (DCT). Why is DCT preferred over the Discrete Fourier Transform (DFT) here?
(A) DCT yields complex coefficients preserving critical phase
(B) DCT automatically removes additive background audio noise
(C) DCT compacts most energy into lower-order coefficients
(D) DCT maps the logarithmic frequency back to a linear scale

2003

115. Arrange the following steps of Linear Predictive Coding (LPC) analysis in the correct sequential order:
I. Compute the autocorrelation coefficients
II. Apply a window function (e.g., Hamming) to the speech frame
III. Solve the Yule-Walker equations using Levinson-Durbin
IV. Calculate the prediction error (residual)
Select the correct logical sequence:
(A) II, I, III, IV
(B) I, II, III, IV
(C) II, III, I, IV
(D) III, II, I, IV

2023

116. In the Autocorrelation method of LPC, the windowing is applied to the signal prior to computing the autocorrelation. What is a primary theoretical disadvantage of this step?
(A) It yields an unstable estimated all-pole filter system
(B) It strictly requires processing of infinite length sequences
(C) It prevents the use of efficient Levinson-Durbin algorithms
(D) It distorts frame edges, modifying the spectral envelope

2012

117. The Levinson-Durbin algorithm solves a system of equations iteratively. At each step m, what specific filter parameter is computed directly to update the predictor?
(A) The reflection coefficient k_m
(B) The resonant formant frequency
(C) The log Mel-scale filter energy
(D) The fundamental pitch period T_0

2008

118. When an LPC predictor is designed optimally for a specific speech frame, the spectrum of the resulting prediction error (residual) is ideally:
(A) Exactly equal to the speech spectrum
(B) Strongly peaked at formant frequencies
(C) Spectrally flat (white)
(D) Strongly peaked at anti-resonances

2025

119. In a continuous speech recognition system, what is the primary structural challenge that distinguishes it from isolated word recognition?
(A) The absence of clear word boundaries (coarticulation)
(B) The vocabulary size must be smaller
(C) The inability to use Mel-Frequency Cepstral Coefficients
(D) The requirement for parametric vocoding

NODIA

2018

120. Dynamic Time Warping (DTW) calculates the distance between two feature sequences. The overall optimal alignment path is found by minimizing what metric?
(A) The maximum localized spectral difference
(B) The cross-correlation lag
(C) The variance of the feature vectors
(D) The accumulated global distance

2025

121. Consider the following statements about Gaussian Mixture Models (GMM) in HMM-based ASR:
I. GMMs model the multi-modal nature of acoustic feature distributions.
II. The number of mixture components dictates the resolution of the model.
III. Diagonal covariance matrices are often used because MFCCs are largely uncorrelated.
IV. GMMs directly model the sequence of words in a sentence.
V. GMM parameters are typically trained using the Baum-Welch algorithm.

additive
(B) The phase spectra are strictly additive across frames
(C) The cepstral coefficients are multiplicatively related in time
(D) The fundamental pitch periods are completely identical

2016
48. Wiener filtering for speech enhancement depends on the estimation of which statistical parameter?
(A) Fundamental frequency trajectory
(B) Glottal flow derivative
(C) A priori signal-to-noise ratio (SNR)
(D) Autocorrelation of the reflection coefficients

2005
49. In pitch-synchronous processing of speech signals, operations are aligned with which specific physiological event?
(A) The physiological opening of the velum
(B) The complete physical closure of the lips
(C) The rapid movement of the active tongue tip
(D) The periodic glottal closure instants

2008
50. Consider the following statements regarding comb filtering in speech enhancement:
I. It exploits the harmonic structure of voiced speech.
II. It attenuates frequencies that fall exactly on the pitch harmonics.
III. It improves the signal-to-noise ratio of unvoiced speech.
IV. The filter delay is typically set to the pitch period.
V. It can suppress broadband noise lying between harmonics.
Which of the above statements are correct?
(A) I, II and IV
(B) I, IV and V
(C) II, III and V
(D) I, III and IV

2013
51. Which muscle is primarily responsible for controlling the tension of the vocal cords, thereby altering the fundamental frequency of phonation?
(A) Posterior cricoarytenoid
(B) Cricothyroid
(C) Genioglossus
(D) Orbicularis oris

2001
52. Plosive consonants are characterized acoustically by three distinct phases. Which of the following is NOT one of these phases?
(A) Complete closure and silence
(B) Explosive burst and release
(C) Brief frication or aspiration
(D) Sustained harmonic resonance

2005
53. If the length of a uniform vocal tract is approximated as 17 cm, what is the approximate first formant frequency (F_1) assuming the speed of sound is 340 m/s?
(A) 250 Hz
(B) 500 Hz
(C) 1000 Hz
(D) 1500 Hz

2010
54. Auditory masking in the human ear is highly asymmetrical. Which statement correctly describes this asymmetry?
(A) High-frequency sounds mask low-frequency sounds more effectively
(B) Unvoiced sounds mask voiced sounds more effectively
(C) Low-frequency sounds mask high-frequency sounds more effectively
(D) Short-duration sounds mask long-duration sounds more effectively

2025
55. Aliasing in digitized speech can be completely avoided if the sampling frequency f_s and the maximum signal frequency f_m satisfy which relation?
(A) $f_s \geq 2f_m$
(B) $f_s \leq f_m$
(C) $f_s = \frac{f_m}{2}$
(D) $f_s \geq f_m$

2009
56. What is the fundamental difference between uniform and non-uniform quantization?
(A) Uniform quantization requires a non-linear compander circuit
(B) Uniform quantization achieves a constant signal-to-noise ratio
(C) Non-uniform quantization is only applicable to unvoiced signals
(D) Non-uniform quantization varies step size based on signal amplitude

Click Here to Buy book on Flipkart

2021

57. Match the encoding schemes in List I with their primary defining features in List II:

List I: Encoding Schemes

P. Pulse Code Modulation (PCM)

Q. Delta Modulation (DM)

R. Adaptive DPCM (ADPCM)

S. Linear Predictive Coding (LPC)

List II: Primary Defining Features

1. Transmits only a 1-bit difference per sample
2. Direct uniform or non-uniform quantization of samples
3. Extracts and transmits vocal tract and excitation parameters
4. Dynamically scales quantization steps based on prediction error

Which of the following is the correct matching?

(A) P-2, Q-1, R-4, S-3

(B) P-1, Q-2, R-3, S-4

(C) P-3, Q-1, R-4, S-2

(D) P-2, Q-4, R-1, S-3

2012

58. Granular noise in Delta Modulation can be minimized by making which structural change to the system?

(A) Increasing the step size

(B) Decreasing the sampling rate

(C) Decreasing the step size

(D) Removing the integrator

2024

59. In CELP coding, how is the optimal excitation vector typically chosen?

(A) Through an open-loop search minimizing the residual signal energy

(B) By passing the unquantized residual directly through the filter

(C) By applying the Levinson-Durbin algorithm to the codebook vectors

(D) Through a closed-loop search minimizing perceptually weighted error

2021

60. Frame blocking divides a continuous speech signal into short frames. Why is overlapping typically applied between adjacent frames?

(A) To compensate for window attenuation at frame boundaries

(B) To significantly reduce the total number of computed frames

(C) To prevent frequency-domain aliasing during reconstruction

(D) To guarantee the signal remains stationary over long periods

2007

61. The time-frequency resolution of a spectrogram is fundamentally limited by which mathematical principle?

(A) Parseval's energy theorem

(B) Heisenberg-Gabor principle

(C) Nyquist-Shannon theorem

(D) Wiener-Khinchin theorem

2005

62. Given below are an Assertion (A) and a Reason (R):

Assertion (A): A narrowband spectrogram is best suited for accurately determining formant frequencies.

Reason (R): A narrowband spectrogram uses a long time window, providing high frequency resolution.

Which of the following is correct?

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is NOT the correct explanation of A.

(C) A is true but R is false.

(D) A is false but R is true.

NODIA

2017

63. In the complex cepstrum, what component typically appears as a distinct peak at a specific quefrency index for voiced speech?

(A) The fundamental pitch period

(B) The first formant bandwidth

(C) The unvoiced frication energy

(D) The vocal tract filter shape

2005

64. Mel-frequency scale maps acoustic frequency to perceptual frequency. Which statement best describes this mapping?

(A) Logarithmic below 1 kHz, linear above 1 kHz

(B) Linear below 1 kHz, logarithmic above 1 kHz

(C) Exponential across all frequencies

(D) Strictly logarithmic across all frequencies

2002

65. The all-pole model used in LPC is exceptionally proficient at modeling which acoustic feature of speech?

(A) Anti-resonances in nasal consonants

(B) Broadband noise in fricatives

(C) Resonances (formants) in vowels

(D) Silence intervals in plosives

2012

66. When computing LPC coefficients via the Autocorrelation method, the resulting

autocorrelation matrix possesses which structural property?
(A) It is an identity matrix
(B) It is a diagonal matrix
(C) It is an orthogonal matrix
(D) It is a Toeplitz matrix

2014
67. The reflection coefficients (k-parameters) derived from the Levinson-Durbin recursion are guaranteed to be within what range for a stable filter?
(A) Less than -1
(B) Between -1 and 1
(C) Between 0 and 1
(D) Greater than 1

2014
68. Residual analysis in LPC aims to evaluate the prediction error. For perfectly periodic voiced speech, what should the theoretical residual resemble?
(A) White Gaussian noise
(B) A single decaying exponential
(C) A continuous sine wave at the first formant frequency
(D) A sequence of impulses spaced by the pitch period

2010
69. Order the fundamental stages of building a standard HMM-based speech recognition system:
I. Feature Extraction (e.g., MFCCs)
II. Decoding (Viterbi Search)
III. Language Modeling
IV. Acoustic Modeling (Training HMM/GMM)
Select the correct logical order for system development and execution:
(A) I, IV, III, II
(B) IV, III, I, II
(C) I, III, IV, II
(D) III, IV, II, I

2004
70. In isolated word recognition using Dynamic Time Warping (DTW), what is the function of local path constraints?
(A) To restrict the vocabulary size of the system
(B) To normalize the background noise energy
(C) To prevent the warping path from reversing in time
(D) To increase the dimensionality of the feature vectors

2009
71. In Gaussian Mixture Models (GMM) used for acoustic modeling, what mathematical algorithm is conventionally used to estimate the mixture parameters during training?
(A) Expectation-Maximization Algorithm
(B) Iterative Levinson-Durbin Algorithm
(C) standard Cooley-Tukey FFT Algorithm
(D) Discrete Fast Fourier Transform method

2002
72. Consider the following feature compensation techniques for robust speech recognition:
I. Cepstral Mean Subtraction (CMS)
II. Spectral Subtraction
III. Vocal Tract Length Normalization (VTLN)
IV. Cepral Variance Normalization (CVN)
Identify the combination of techniques that primarily address convolutional noise (channel distortion) in the cepstral domain:
(A) I and II
(B) I and IV
(C) II and III
(D) III and IV

2014
73. Spectral subtraction relies heavily on the operation of a Voice Activity Detector (VAD). What is the primary role of the VAD in this context?
(A) To detect voiced speech segments for pitch tracking
(B) To estimate noise during non-speech intervals
(C) To calculate fundamental frequency of the speaker
(D) To separate formants from the harmonic structure

2023
74. Wiener filtering operates under the assumption that the speech and noise signals are statistically:
(A) Correlated
(B) Identical
(C) Non-stationary within a frame
(D) Uncorrelated

2025
75. Perceptual noise masking criteria in speech enhancement attempt to shape the residual noise so that it is:
(A) Completely eliminated at the cost of speech distortion
(B) Shifted to frequency bands where speech energy is highest
(C) Modulated to sound like a uniform white noise

NODIA

(C) To decorrelate the log-filterbank energies
(D) To compute the absolute phase of the signal

2009

39. In Linear Predictive Coding (LPC), the error signal is defined as the difference between the actual speech sample and what?
(A) The linearly predicted value
(B) The previous speech sample
(C) The mean of the speech frame
(D) The glottal excitation model output

2019

40. Given below are an Assertion (A) and a Reason (R):
Assertion (A): The Covariance method for LPC analysis does not guarantee the stability of the estimated all-pole filter.
Reason (R): The Covariance method applies a window function directly to the speech signal before error minimization.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2025

41. What is the primary output of the Levinson-Durbin algorithm when applied to speech processing?
(A) Mel-frequency filter bank log energy coefficients
(B) LPC predictor and reflection coefficients
(C) Gaussian Mixture Model state parameter sets
(D) The continuous unwrapped phase spectrum

2007

42. Formant estimation using LPC parameters typically involves which mathematical procedure?
(A) Integrating the magnitude spectrum
(B) Calculating the cross-correlation of adjacent frames
(C) Finding the roots of the predictor polynomial
(D) Applying Dynamic Time Warping to the residual

2023

43. Consider the following statements regarding Dynamic Time Warping (DTW):
I. DTW handles temporal variations in speaking rate.
II. DTW aligns a test sequence with a reference template.
III. DTW strictly requires reference and test sequences to have identical lengths.
IV. DTW employs dynamic programming for optimal alignment.
Which of the above statements are correct?
(A) I, II and III
(B) I, II and IV
(C) II, III and IV
(D) I, III and IV

2005

44. In HMM-based speech recognition, the Viterbi algorithm is utilized for which specific task?
(A) Finding the most likely sequence of hidden states
(B) Estimating the parameters of continuous Gaussian mixtures
(C) Computing the Mel-frequency cepstral coefficients of frames
(D) Minimizing the average spectral distortion of the audio signal

2006

45. Which of the following best describes the acoustic modeling component of a modern speech recognition system?
(A) It determines the syntactic and grammatical validity of a recognized sentence
(B) It models the probability of acoustic features given phonetic states
(C) It maps sequences of sub-word phonetic segments to standard vocabulary words
(D) It provides a comprehensive lexicon containing all possible vocabulary words

2005

46. What is the primary goal of applying phase estimation techniques in advanced speech enhancement?
(A) To compress the dynamic range of the residual stationary noise
(B) To improve speech quality beyond magnitude-only methods
(C) To calculate the exact fundamental frequency of unvoiced speech
(D) To convert the audio signal into a parametric vocoder format

2017

47. Which mathematical property describes the relationship between the magnitude spectrum of clean speech, noise, and noisy speech assumed in standard spectral subtraction?
(A) The power spectra are approximately

Downloaded from www.pdf.tube

2019

85. The Hanning window differs from the Rectangular window in short-time processing by effectively reducing which specific artifact?
(A) Spectral leakage (side-lobe amplitude)
(B) Time-domain signal reconstruction aliasing
(C) Computational complexity of the FFT algorithm
(D) Phase wrapping errors during cepstrum calculation

2023

86. Match the window functions in List I with their defining characteristics in List II:
List I: Window Functions
P. Rectangular Window
Q. Hamming Window
R. Hanning Window
S. Blackman Window
List II: Defining Characteristics
1. Zero at edges, smooth cosine shape
2. Narrowest main lobe, highest side lobes
3. Tapered cosine shape, does not reach zero at edges
4. Very wide main lobe, extremely low side lobes
Which of the following is the correct matching?
(A) P-2, Q-3, R-1, S-4
(B) P-1, Q-2, R-3, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-1, R-4, S-3

2011

87. In homomorphic processing, the operation applied after taking the logarithm of the magnitude spectrum to obtain the cepstrum is:
(A) Inverse Fourier Transform
(B) Mathematical integration
(C) Temporal differentiation
(D) Signal autocorrelation

2004

88. Liftering in the cepstral domain is analogous to which operation in the frequency domain?
(A) Modulation
(B) Sampling
(C) Quantization
(D) Filtering

2024

89. Which property of Mel-Frequency Cepstral Coefficients (MFCCs) makes them particularly effective for statistical pattern recognition using GMMs?
(A) They preserve the exact time-domain phase structure of the signal
(B) They are uncorrelated, allowing diagonal covariance matrices
(C) They exhibit high statistical correlation with adjacent coefficients
(D) They perfectly model and track the fundamental frequency of speech

2022

90. What is the fundamental assumption made about the excitation signal in the all-pole model of Linear Predictive Coding (LPC) for unvoiced speech?
(A) It is a periodic impulse train excitation
(B) It is a single pure sinusoidal wave carrier
(C) It is a flat-spectrum random noise sequence
(D) It is an exponentially decaying analog pulse

NODIA

2010

91. In solving LPC equations, the Covariance method constructs a matrix that is symmetric but generally lacks which specific property found in the Autocorrelation method?
(A) Positive definiteness
(B) Invertibility
(C) Real values
(D) Toeplitz structure

2016

92. The partial correlation (PARCOR) coefficients are an intermediate result of which computational algorithm used in speech processing?
(A) Levinson-Durbin recursion
(B) Viterbi decoding process
(C) Cooley-Tukey FFT algorithm
(D) Expectation-Maximization method

2017

93. When utilizing LPC parameters for formant estimation, the bandwidths of the formants are derived from which characteristic of the polynomial roots?
(A) The angular phase angle of the predictor roots
(B) The radius of the polynomial roots in the z -plane
(C) The summation of all estimated polynomial roots
(D) The real part of the inverse of the predictor roots

2010

94. A lexicon in an automatic speech recognition (ASR) system primarily defines the mapping between which two linguistic units?
(A) Acoustic frames and triphone states
(B) Words and their phonemic spellings

(C) Sentences and grammatical syntax rules
(D) Morphemes and semantic dictionary meaning

2011
95. The problem of evaluating the probability of an observation sequence given an HMM model is optimally solved by which algorithm?
(A) Forward algorithm
(B) Viterbi algorithm
(C) Baum-Welch algorithm
(D) K-means clustering

2023
96. Consider the following statements about Hidden Markov Models (HMM) in speech recognition:
I. The Markov assumption states that the current state depends only on the previous state.
II. Emission probabilities model the likelihood of observing acoustic features given a state.
III. Transition probabilities model the temporal evolution between phonetic states.
IV. HMMs inherently ignore the time-sequential nature of speech.
Which of the above statements are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2008
97. In robust speech recognition, what does the RASTA (RelAtive SpecTrAl) processing technique primarily accomplish?
(A) It performs deep neural network acoustic modeling directly on raw speech signals
(B) It modifies language model probabilities dynamically depending on channel noise
(C) It extracts speaker fundamental frequency trajectories dynamically across frames
(D) It bandpass filters feature temporal trajectories to suppress steady noise

2005
98. When implementing spectral subtraction, an overestimation factor is often applied to the noise estimate. What is the primary reason for this?
(A) To enhance the fundamental frequency
(B) To compensate for the inaccuracy of the Voice Activity Detector
(C) To further reduce the remaining musical noise artifacts
(D) To increase the overall amplitude of the enhanced speech

2011
99. The Wiener filter for speech enhancement is derived by minimizing the Mean Square Error (MSE) under the assumption that speech and noise are independent and wide-sense stationary. In practice, how is this stationarity assumption addressed?
(A) By using extremely long, quasi-infinite temporal windowing functions
(B) By filtering in the STFT domain using short overlapping frames
(C) By completely removing phase information from the speech spectrum
(D) By applying the adaptive filter exclusively within the time domain

2012
100. Given below are an Assertion (A) and a Reason (R):
Assertion (A): Comb filtering is highly effective for enhancing unvoiced fricatives in noisy environments.
Reason (R): Comb filters rely on detecting and preserving strict harmonic structures spaced by the fundamental frequency.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2012
101. The Bernoulli effect plays a crucial role in which aspect of human speech production?
(A) The closing phase of vocal folds during phonation
(B) The acoustic resonance of the nasal cavity tract
(C) The turbulent airflow generation at the incisor teeth
(D) The dynamic elevation and movement of the velum tissue

2013
102. Which specific acoustic cue is most critical for distinguishing between voiced and unvoiced plosives (e.g., /b/ vs. /p/) at the start of a syllable?
(A) Second formant transition
(B) First formant steady-state frequency
(C) Voice Onset Time (VOT)
(D) Spectral tilt

Click Here to Buy book on Amazon

2010

103. In the context of the source-filter theory, modifying the shape of the oral cavity by moving the tongue affects which component?
(A) The filter transfer function
(B) The source excitation spectrum
(C) The glottal flow derivative
(D) The fundamental frequency contour

2002

104. Which concept relates to the fact that the human auditory system integrates acoustic energy over specific frequency bands to determine loudness?
(A) Mel-scale wrapping
(B) Phase locking
(C) Homomorphic deconvolution
(D) Critical bands

2009

105. When digitizing a speech signal, if the input contains frequency components above the Nyquist limit, what specific artifact will corrupt the digital signal?
(A) Granular noise
(B) Aliasing
(C) Slope overload
(D) Quantization clipping

2024

106. In A-law companding used in digital telephony, the 'A' parameter determines what aspect of the compression?
(A) The overall transmission bit rate of the channel
(B) The cut-off frequency of the internal low-pass filter
(C) The degree of compression applied to signal amplitude
(D) The sampling rate scaling factor of the A/D converter

2014

107. Delta Modulation (DM) represents a signal using a 1-bit quantizer. This bit essentially signifies the sign of what value?
(A) The absolute amplitude of the incoming signal sample
(B) The phase derivative computed for the speech sample
(C) The instantaneous frequency of the analog signal sample
(D) The difference between current and predicted samples

2001

108. The predictor in a Differential Pulse Code Modulation (DPCM) system relies on which property of speech signals to achieve coding gain?
(A) High sample-to-sample correlation
(B) High variance of unvoiced segments
(C) Randomness of the phase spectrum
(D) Independence of adjacent frames

2008

109. Code-Excited Linear Prediction (CELP) achieves high-quality speech at low bit rates by modeling the excitation source utilizing which two distinct components?
(A) A pitch filter combined with a white noise shaping filter
(B) An adaptive codebook and a stochastic (fixed) codebook
(C) A magnitude spectrum and its corresponding phase spectrum
(D) An HMM state sequence matched with a GMM emission model

2004

110. In short-time speech processing, what is the consequence of selecting a rectangular window instead of a Hamming window?
(A) Increased main-lobe bandwidth
(B) Increased spectral leakage
(C) Decreased temporal resolution
(D) Complete loss of DC component

2014

111. Consider the following statements about the Short-Time Fourier Transform (STFT):
I. It assumes the signal is stationary within the analysis window.
II. It provides a purely continuous representation in both time and frequency domains.
III. Overlapping windows are used to mitigate artifacts at frame boundaries.
IV. Time-frequency resolution is strictly dependent on window length.
Which of the above statements are correct?
(A) I, II and III
(B) I, III and IV
(C) II, III and IV
(D) I, II and IV

NODIA

2022

112. When analyzing a wideband spectrogram of voiced speech, what do the distinct vertical striations represent?
(A) Harmonics of fundamental frequency
(B) Resonant formant bandwidths

(D) Kept below the auditory masking threshold of the clean speech

2013

76. The arytenoid cartilages in the larynx are directly responsible for which action during speech production?
(A) Abduction and adduction of the vocal folds
(B) Elevating the soft palate during speech
(C) Modifying the dynamic shape of the lips
(D) Retracting the root of the tongue body

2018

77. Affricate phonemes, such as /t∫/ in "church", consist of a sequential combination of which two phonetic classes?
(A) Fricative followed by a nasal
(B) Plosive followed by a fricative
(C) Approximant followed by a vowel
(D) Nasal followed by a plosive

2006

78. In the context of the source-filter model, the radiation characteristic at the lips is typically modeled as what kind of filter?
(A) Low-pass filter
(B) High-pass filter
(C) Band-pass filter
(D) All-pass filter

2004

79. What psychoacoustic measure is used to quantify the perceived pitch of a complex tone?
(A) Mels
(B) Sones
(C) Phons
(D) Bels

2021

80. Given below are an Assertion (A) and a Reason (R):
Assertion (A): An anti-aliasing filter is required before the Analog-to-Digital conversion of speech.
Reason (R): Frequencies above the Nyquist rate fold back into the baseband, causing irreversible distortion.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2015

81. In μ-law companding, the compression characteristic is defined by the parameter μ. A higher value of μ results in which outcome?
(A) Less compression and greater dynamic range
(B) Strictly linear quantization across all levels
(C) Elimination of quantization noise entirely
(D) Greater compression for low-level signals

2018

82. Which statement accurately describes the operation of a Delta Modulator at the receiver end?
(A) It applies an inverse Fourier transform computation to the received bits
(B) It decodes the cepstral coefficients directly into the speech waveform
(C) It passes the bitstream through an integrator and a low-pass filter
(D) It employs a complex multi-state Viterbi decoder for reconstruction

2016

83. Why does Adaptive Differential Pulse Code Modulation (ADPCM) exhibit superior performance to standard DPCM over non-stationary speech segments?
(A) It transmits predictive parameters directly in the frequency domain
(B) It dynamically adapts its predictor and quantizer step size
(C) It completely removes the requirement for a physical sampling clock
(D) It selectively codes high-frequency unvoiced speech segments

2022

84. Consider the following statements regarding modern speech coding algorithms:
I. Parametric vocoders typically achieve bitrates below 4 kbps.
II. Waveform coders preserve the exact phase of the original signal.
III. CELP is a hybrid coder utilizing both waveform and parametric principles.
IV. Linear predictive coding primarily focuses on phase reconstruction.
Which of the above statements are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

Downloaded from www.pdf.tube

Which of the above statements are correct?
(A) I, II, III and V
(B) I, III, IV and V
(C) II, III, IV and V
(D) I, II, IV and V

2002

122. Which condition must be met for Cepstral Mean Subtraction (CMS) to effectively remove channel effects?
(A) The channel distortion must be additive in the signal domain
(B) The channel distortion must vary rapidly over the spoken utterance
(C) The channel response must be linear and time-invariant over time
(D) The speech signal must be perfectly periodic across frames

2016

123. Given below are an Assertion (A) and a Reason (R):
Assertion (A): Standard spectral subtraction can cause severe degradation of speech intelligibility at very low SNRs.
Reason (R): Heavy noise overestimation creates large artificial gaps in the speech spectrum, leading to musical noise and signal distortion.
Which of the following is correct?
(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false but R is true.

2008

124. In Wiener filtering for speech enhancement, the filter transfer function $H(\omega)$ is generally formulated based on which specific spectral ratio?
(A) Clean speech power spectrum to noisy speech power spectrum
(B) Clean speech power spectrum to estimated noise power spectrum
(C) Noise power spectrum to clean speech power spectrum ratio
(D) Clean speech magnitude spectrum to noise magnitude spectrum ratio

2022

125. Pitch-synchronous processing requires highly accurate detection of which parameter to avoid introducing distortion?
(A) Formant bandwidth trajectories
(B) Glottal closure instants (GCIs)
(C) Unvoiced frication duration times
(D) Vowel onset time boundaries

NODIA

2015

126. Match the speech enhancement concepts in List I with their operational domains in List II:
List I: Speech Enhancement Concepts
P. Spectral Subtraction
Q. Wiener Filtering
R. Comb Filtering
S. Cepstral Mean Subtraction
List II: Operational Domains
1. Minimum Mean Square Error optimization
2. Magnitude spectrum manipulation
3. Harmonic enhancement via delayed signals
4. Feature domain normalisation
Which of the following is the correct matching?
(A) P-2, Q-1, R-3, S-4
(B) P-1, Q-2, R-4, S-3
(C) P-3, Q-4, R-1, S-2
(D) P-2, Q-3, R-1, S-4

2011

127. The vocal tract acts as a resonant cavity. If the tract is modeled as a uniform tube closed at one end (glottis) and open at the other (lips), the resonant frequencies are proportional to:
(A) Odd multiples of the quarter-wavelength frequency
(B) Even multiples of the system fundamental frequency
(C) The exact square root of the acoustic tube length
(D) The mathematical inverse of the internal air density

2009

128. Nasal consonants (e.g., /m/, /n/) possess unique acoustic characteristics compared to oral consonants primarily due to the presence of:
(A) Highly turbulent airflow generated at the lip boundaries
(B) A complete absence of the fundamental pitch frequency
(C) Anti-resonances in the spectral transfer function
(D) An extremely wide and damp first formant bandwidth

2004

129. The concept of "critical bands" implies that the human ear acts conceptually as a bank of:
(A) Uniformly spaced auditory bandpass filters
(B) Logarithmically spaced analog high-pass

telecommunication systems use a sampling rate of:
(A) 4 kHz
(B) 8 kHz
(C) 16 kHz
(D) 44.1 kHz

2012
181. Match the quantization parameters in List I with their practical effects in speech coding in List II:
List I: (Quantization Parameters)
P. Number of bits per sample
Q. Companding law (A/μ)
R. Sampling rate
S. Adaptive step size
List II: (Practical Effects)
1. Dictates the highest unaliased frequency
2. Controls the dynamic range and SQNR balance
3. Determines the overall uniform SQNR
4. Minimizes slope overload and granular noise
Select the correct option:
(A) P-3, Q-2, R-1, S-4
(B) P-2, Q-3, R-1, S-4
(C) P-3, Q-1, R-4, S-2
(D) P-1, Q-4, R-2, S-3

2001
182. A Delta Modulator suffers from slope overload. Which hardware adjustment can directly alleviate this problem?
(A) Decreasing the sampling rate
(B) Applying a high-pass filter to the input
(C) Using a rectangular window
(D) Increasing the step size

2016
183. Adaptive Differential Pulse Code Modulation (ADPCM) updates its quantizer step size based on the memory of past quantized values. This specific adaptation type is known as:
(A) Forward adaptation
(B) Backward adaptation
(C) Open-loop adaptation
(D) Pitch-synchronous adaptation

2022
184. In parametric vocoders, which parameter dictates whether the synthesizer utilizes a pulse train generator or a random noise generator?
(A) The dynamic formant frequencies
(B) The scale of the gain coefficient
(C) The voiced/unvoiced decision
(D) The estimated predictor coefficients

2001
185. A windowing function multiplies the speech signal in the time domain. Mathematically, what does this operation correspond to in the frequency domain?
(A) Algebraic addition of the window's spectrum to the signal spectrum
(B) Complex division of the signal spectrum by the window's spectrum
(C) Mathematical differentiation of the continuous signal spectrum
(D) Convolution of the signal spectrum with the window's spectrum

2007
186. Which parameter inherently determines the trade-off between time and frequency resolution in the Short-Time Fourier Transform (STFT)?
(A) The length (duration) of the analysis window
(B) The sampling rate of the analog-to-digital converter
(C) The physical type and frequency response of the microphone
(D) The maximum amplitude envelope of the input speech signal

2019
187. Narrowband spectrograms typically utilize an analysis window of approximately what length?
(A) 1-3 ms
(B) 5-10 ms
(C) 20-30 ms
(D) 100-200 ms

2010
188. In computing the complex cepstrum, the logarithm function separates the source and filter components. What mathematical relationship between source and filter in the frequency domain makes this possible?
(A) They are additive in nature
(B) They are multiplicative
(C) They are strictly orthogonal
(D) They are completely independent

2014
189. Consider the following steps for Mel-Frequency Cepstral Coefficients (MFCC) extraction:
I. Frame Blocking and Windowing
II. Mel-filterbank application
III. Discrete Cosine Transform (DCT)
IV. Fast Fourier Transform (FFT)
Which of the following represents the correct operational order of these steps?
(A) I, IV, II, III
(B) I, II, IV, III

Click Here to Buy book on Flipkart

STUDYING FROM PDFs?

THINK AGAIN.

If you are studying only from PDFs,
you are wasting valuable time.

Research shows that learning from

PRINTED BOOKS has up to

4× HIGHER RETENTION

than studying from screens.

PRINT BOOK = BETTER MEMORY

PDF = LOWER RETENTION

Those who study from **PRINTED BOOKS**
move **AHEAD.**

Others are left **BEHIND**
in competition.

In competitive exams,
being average is not enough.

STAY ONE STEP AHEAD.

$\frac{G}{1-\sum_{k=1}^{p} a_k z^{-k}}$. What do the parameters a_k represent?

(A) The filter gain
(B) The predictor coefficients
(C) The reflection coefficients
(D) The cepstral coefficients

2019

140. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Read both statements carefully and select the correct option.

Assertion (A): The Autocorrelation method of LPC always yields a minimum-phase synthesis filter.

Reason (R): The roots of the predictor polynomial formed by the Autocorrelation method strictly lie inside the unit circle.

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2001

141. The Levinson-Durbin algorithm reduces the computational complexity of solving the Yule-Walker equations from $O(p^3)$ down to:

(A) $O(p)$
(B) $O(p \log p)$
(C) $O(p^2)$
(D) $O(2^p)$

2021

142. When using LPC for formant estimation, why might closely spaced formants be difficult to resolve?

(A) LPC strictly forces the estimated formants to be equally spaced across the frequency band
(B) The Autocorrelation method always places all of the polynomial roots on the real axis
(C) LPC models smooth over the spectral peaks if the predictor order is too low
(D) Formants are inherently masked by the spectral variation of the fundamental frequency

2018

143. In a Hidden Markov Model (HMM) framework, acoustic modeling involves computing $P(O \mid W)$. According to Bayes' Theorem, what must this be combined with to find the most likely word sequence W?

(A) The complete state emission probability $P(O)$
(B) The state transition probability matrix A
(C) The overall optimal Viterbi path score
(D) The language model probability $P(W)$

2007

144. What is the fundamental limitation of isolated word recognition systems using Dynamic Time Warping (DTW) as vocabulary size increases?

(A) The input sampling rate must be proportionally increased to maintain accuracy
(B) DTW algorithms cannot handle male and female speaker profiles simultaneously
(C) The computational and template storage requirements grow linearly or faster
(D) DTW strictly requires parametric coding, which severely degrades word boundaries

2025

145. Match the components of an Automatic Speech Recognition (ASR) system in List I with their corresponding mathematical formulations in List II:

List I: (ASR System Components)
P. Acoustic Model
Q. Language Model
R. Feature Extraction
S. Decoder Search

List II: (Mathematical Formulations)
1. $\text{argmax}_W P(W \mid O)$
2. $P(O \mid W)$
3. $P(W)$
4. $x(n) \rightarrow \mathbf{o}_t$

Select the correct option:
(A) P-1, Q-2, R-3, S-4
(B) P-2, Q-3, R-4, S-1
(C) P-3, Q-1, R-4, S-2
(D) P-2, Q-4, R-1, S-3

2022

146. Which technique provides a robust mechanism to handle additive background noise directly within the HMM statistical framework, rather than in the feature extraction stage?

(A) Cepstral Mean Subtraction (CMS) technique
(B) RelAtive SpecTrAl (RASTA) filtering
(C) Homomorphic Deconvolution method
(D) Parallel Model Combination (PMC)

Downloaded from www.pdf.tube

2007

164. In computing Mel-Frequency Cepstral Coefficients (MFCC), the triangular filter banks are designed such that:
(A) They have strictly uniform and equal bandwidths across all frequencies
(B) They overlap precisely and equally in the linear frequency domain
(C) They become wider and overlap more at higher frequencies
(D) They are constrained to only cover the fundamental frequency range

2002

165. The all-pole model of the vocal tract is mathematically equivalent to which type of digital filter?
(A) Infinite Impulse Response (IIR) filter
(B) Finite Impulse Response (FIR) filter structure
(C) Non-linear median smoothing filter
(D) Standard moving average digital filter

2003

166. Consider the following statements comparing the Autocorrelation and Covariance methods for Linear Predictive Coding (LPC):
I. The Covariance method does not use a tapering window on the signal.
II. The Autocorrelation method guarantees filter stability.
III. The Covariance method matrix is always Toeplitz.
IV. The Autocorrelation method uses data outside the analysis frame by assuming zero values.
Which of the above statements are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2023

167. The reflection coefficients in LPC can be directly transformed into another set of parameters that are robust to quantization errors for transmission. What are these called?
(A) Discrete Cosine Transform Coefficients
(B) Line Spectral Frequencies (LSFs)
(C) Mel-scale Filter Bank coefficients
(D) Complex Cepstral Coefficients

2024

168. If the LPC predictor order p is set too high (e.g., $p = 50$ for 8 kHz speech), what is the most likely detrimental effect on the estimated spectral envelope?
(A) It completely fails to accurately model the first formant frequency and its bandwidth
(B) It flattens the estimated spectral envelope of the signal across all frequency bands
(C) It models the fine harmonic structure instead of the smooth vocal tract envelope
(D) It forces all of the predictor polynomial roots to lie strictly outside the unit circle

2001

169. What is the fundamental role of the acoustic model in a standard HMM-based Automatic Speech Recognition (ASR) system?
(A) To calculate the overall prior probability of a specific word sequence
(B) To parse the grammatical correctness and syntactic structure of recognized text
(C) To normalize and align the speaking rate variations across different users
(D) To evaluate $\mathrm{P}(\text{acoustic features} \mid \text{phonetic state})$

2015

170. Dynamic Time Warping (DTW) allows non-linear mapping between a reference and a test signal. What is a primary condition generally imposed on the warping path?
(A) The path must be monotonically non-decreasing
(B) The path must strictly jump by at least 2 steps per frame
(C) The path must always follow the main diagonal precisely
(D) The path must allow time-reversal to match similar sounds

2012

171. In Gaussian Mixture Models (GMM) applied to speech recognition, a diagonal covariance matrix is generally utilized because:
(A) It accurately models the highly complex and strong correlation between adjacent MFCCs
(B) MFCC features are approximately uncorrelated, saving immense computational load
(C) It forces all of the individual Gaussian clusters to overlap precisely in space
(D) It completely eliminates the mathematical need for the Expectation-Maximization algorithm

NODIA

2007

156. In the context of A-law companding, what happens to the quantization step size as the signal amplitude increases?
(A) It remains constant
(B) It increases
(C) It decreases linearly
(D) It decreases exponentially

2016

157. Slope overload in Delta Modulation can be mathematically described by which condition, where Δ is the step size, T_s is the sampling period, and $m(t)$ is the message signal?
(A) $\frac{\Delta}{T_s} < \left|\frac{dm(t)}{dt}\right|$
(B) $\frac{\Delta}{T_s} > \left|\frac{dm(t)}{dt}\right|$
(C) $\Delta \cdot T_s = \frac{dm(t)}{dt}$
(D) $\Delta = |m(t)|$

2016

158. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Read both statements carefully and select the correct option.
Assertion (A): DPCM provides a higher Signal-to-Noise Ratio (SNR) than standard PCM at the same bit rate.
Reason (R): DPCM exploits the correlation between successive speech samples, reducing the variance of the signal to be quantized.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2010

159. In CELP coding, the stochastic codebook is generally populated with:
(A) Sine waves of varying fundamental frequencies
(B) Pre-recorded phonetic and phoneme templates
(C) Dynamic formant tracking and trajectories
(D) Random white Gaussian noise sequences

2015

160. Frame blocking typically uses a frame length of 20-30 ms. Why is a 200 ms frame length inappropriate for speech analysis?
(A) The Fast Fourier Transform computation becomes mathematically impossible to perform
(B) The resulting frequency resolution becomes far too poor to accurately identify formants
(C) The speech signal cannot be considered stationary over 200 ms
(D) The windowing function would cause total destructive signal cancellation

2019

161. In the STFT, how does zero-padding the time-domain windowed frame affect the resulting spectrum?
(A) It significantly improves the actual physical frequency resolution of the analyzed signal
(B) It interpolates the spectrum, increasing grid density without improving resolution
(C) It completely eliminates spectral leakage caused by finite windowing of the signal
(D) It perfectly isolates and separates the excitation source from the vocal tract filter

2013

162. Match the spectrographic features in List I with their corresponding speech characteristics in List II:
List I: (Spectrographic Features)
P. Dark horizontal bands
Q. Vertical striations
R. Blank spaces (white regions)
S. High-frequency random dark spots
List II: (Speech Characteristics)
1. Pitch periods (glottal pulses)
2. Silence or closure duration
3. Unvoiced fricative energy
4. Formant frequencies
Select the correct option:
(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-2, R-1, S-3
(C) P-3, Q-1, R-4, S-2
(D) P-4, Q-1, R-2, S-3

2022

163. The real cepstrum is calculated by taking the inverse Fourier transform of the:
(A) Logarithm of the magnitude of the Fourier transform
(B) Logarithm of the absolute phase of the complex Fourier transform
(C) Complex exponential of the un-windowed Fourier transform
(D) Inverse phase angle of the calculated Fourier transform

Click Here to Buy book on Amazon

2010

147. In spectral subtraction, half-wave rectification is often used to handle negative power spectrum estimates. What does this process explicitly do?
(A) Sets all negative spectral estimates to zero
(B) Sets all negative spectral estimates to the absolute magnitude
(C) Inverts the phase of the negative spectral estimates
(D) Averages the negative estimates with the previous frame

2002

148. The generalized Wiener filter formulation includes a parameter α to control the trade-off between:
(A) Pitch resolution and formant resolution
(B) Time resolution and frequency resolution
(C) Noise suppression and speech distortion
(D) Predictor order and quantization noise

2006

149. Consider the following operations for comb filtering in speech enhancement:
I. Estimate the fundamental frequency (pitch) of the current frame
II. Construct a filter with peaks exactly at the pitch harmonics
III. Determine if the frame is voiced or unvoiced
IV. Filter the noisy speech signal
Which of the following represents the correct sequential order of these operations?
(A) III, I, II, IV
(B) I, III, II, IV
(C) II, I, III, IV
(D) I, II, III, IV

2021

150. Perceptual noise masking criteria are derived from psychoacoustics. Which curve is fundamentally used to determine if noise at a specific frequency will be audible?
(A) The absolute threshold of auditory hearing measured in quiet conditions
(B) The non-linear Bark scale frequency mapping curve
(C) The psychoacoustic Equal Loudness Contour (Fletcher-Munson curve)
(D) The global masking threshold calculated from speech energy peaks

2024

151. Which anatomical part is considered the primary articulator responsible for shaping vowel sounds?
(A) The teeth
(B) The tongue
(C) The hard palate
(D) The pharynx

2010

152. Consider the following statements regarding the acoustic characteristics of phonemes:
I. Voiced fricatives contain both a periodic source and a noise source.
II. Plosives are characterized by continuous, high-amplitude harmonic energy.
III. Unvoiced sounds completely lack fundamental frequency (F0) harmonics.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

NODIA

2017

153. Under the source-filter theory, if a speech signal contains significant energy up to 8 kHz, applying a sampling rate of 10 kHz without an anti-aliasing filter will result in an 8 kHz tone folding back to which frequency?
(A) Only the formant frequencies change
(B) Both the harmonic spacing and the formant frequencies change
(C) Neither harmonic spacing nor formant frequencies change
(D) Only the spacing of the harmonic lines changes

2005

154. What is the psychoacoustic significance of the Bark scale in speech processing?
(A) It aligns with the critical bands of human hearing
(B) It maps acoustic frequency linearly to perceptual resolution
(C) It measures the absolute intensity of speech
(D) It predicts the exact fundamental frequency of a speaker

2019

155. If a speech signal contains significant energy up to 8 kHz, applying a sampling rate of 10 kHz without an anti-aliasing filter will result in an 8 kHz tone folding back to which frequency?
(A) 2 kHz
(B) 4 kHz
(C) 5 kHz
(D) 8 kHz

2017

172. Consider the following steps for applying Cepstral Mean Subtraction (CMS) in a robust speech recognition system:

I. Subtract the mean vector from each individual cepstral vector
II. Compute the cepstral feature vectors for the entire utterance
III. Calculate the mean vector of the cepstral features over time
IV. Pass the normalized features to the acoustic model

Which of the following represents the correct sequential order of these steps?

(A) III, I, II, IV
(B) II, III, I, IV
(C) II, I, III, IV
(D) I, II, III, IV

2017

173. What is a primary limitation of using basic Spectral Subtraction for speech enhancement in highly non-stationary noise environments?

(A) The noise estimate cannot adapt quickly enough, leading to severe artifacts
(B) The enhancement algorithm strictly requires parametric speech coding to function
(C) It perfectly removes background noise but completely flattens important speech formants
(D) It inherently and unpredictably shifts the fundamental frequency of the speaker

2023

174. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Read both statements carefully and select the correct option.

Assertion (A): Wiener filtering is optimal for minimizing the mean square error of the enhanced speech signal.

Reason (R): Wiener filtering relies on phase estimation to perfectly reconstruct the time-domain waveform.

(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2022

175. Comb filtering in speech enhancement relies on the periodic nature of voiced speech. Which parameter must be estimated with high precision for comb filtering to be effective?

(A) The estimated first formant frequency of the vowel
(B) The overall spectral tilt of the speech segment
(C) The calculated background noise covariance matrix
(D) The fundamental pitch period

2008

176. Which component of the human speech production mechanism serves as the primary power supply for phonation?

(A) The vocal folds and larynx assembly
(B) The oral cavity and articulators
(C) The lungs and respiratory system
(D) The velopharyngeal port opening

2014

177. Formants are acoustically defined as:

(A) The integer multiples of the fundamental frequency
(B) The resonant frequencies of the vocal tract
(C) The zeros of the nasal tract
(D) The noise bursts of stop consonants

2002

178. Consider the following definitions related to speech production theory:

I. Source: the acoustic excitation (e.g., vocal cord vibration).
II. Filter: the resonant characteristics of the vocal tract.
III. Radiation: the effect of sound radiating from the lips.

Which of the above statements are correct components of the complete speech production model?

(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2019

179. Auditory masking implies that a tone of 1000 Hz will most effectively mask another tone at which frequency?

(A) 200 Hz
(B) 1050 Hz
(C) 3000 Hz
(D) 8000 Hz

2017

180. To accurately digitize a telephone bandwidth speech signal (up to 3.4 kHz), standard

Downloaded from www.pdf.tube

energy)

2006

199. Wiener filtering is considered an optimal linear filter. What statistical metric does it strictly minimize?
(A) Maximum Absolute Error
(B) Mean Square Error (MSE)
(C) Minimum Phase Error
(D) Signal-to-Noise Ratio (SNR)

2010

200. Pitch-synchronous processing requires operations to be synchronized with the glottal cycle. This technique is most commonly used for:
(A) Unvoiced speech enhancement and background noise suppression
(B) White noise generation for stochastic excitation modeling
(C) Prosody modification (e.g., pitch shifting and time scaling)
(D) Computing the Discrete Cosine Transform for feature extraction

2019

201. Comb filtering enhances speech by amplifying which specific components of the noisy speech signal?
(A) The exact spectral regions between the harmonics
(B) The high-frequency unvoiced frication bands
(C) The zero-frequency (DC) component of the signal
(D) The harmonics of the fundamental frequency

2012

202. The glottis is defined as:
(A) The space between the vocal folds
(B) The bony roof of the mouth
(C) The ridge behind the upper teeth
(D) The muscular structure of the tongue

2025

203. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Read both statements carefully and select the correct option.
Assertion (A): The fundamental frequency (F0) of male speakers is generally lower than that of female speakers.
Reason (R): Male vocal folds are typically longer and more massive, vibrating at a slower rate.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2015

204. In acoustic phonetics, the transition of the second formant (F2) into a vowel is the primary cue for identifying the place of articulation of which class of sounds?
(A) Vowels
(B) Plosives
(C) Fricatives
(D) Nasals

2006

205. According to the source-filter theory, the speech spectrum $P(f)$ can be modeled as $P(f) = S(f) \cdot V(f) \cdot R(f)$. What does $R(f)$ represent?
(A) The lip radiation characteristic
(B) The excitation source spectrum
(C) The resonant vocal tract filter
(D) The surrounding room reverberation effect

2007

206. Psychoacoustic critical bands reflect the resolving power of the ear. Which filter bank structure closely mimics this non-linear frequency resolution?
(A) Uniform Filter Bank
(B) Rectangular Filter Bank
(C) Mel-scale Filter Bank
(D) FIR Comb Filter Bank

NODIA

2012

207. If a continuous speech signal is sampled at 8 kHz, the maximum frequency that can be represented without aliasing is:
(A) 2 kHz
(B) 4 kHz
(C) 8 kHz
(D) 16 kHz

2007

208. The standard bit rate for a standard PCM telephone channel using 8 kHz sampling and 8-bit companding (A-law or μ-law) is:
(A) 16 kbps
(B) 32 kbps
(C) 64 kbps
(D) 128 kbps

2022

209. In Delta Modulation, how does the system encode a constant DC input signal?
(A) By transmitting a continuous sequence of all 1s

(C) IV, I, II, III
(D) I, IV, III, II

2005

190. Linear Predictive Coding (LPC) estimates the current speech sample as a linear combination of past samples. The number of past samples used is referred to as the:
(A) Frame size parameter
(B) Pitch period duration
(C) Predictor order
(D) Harmonic count number

2004

191. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Read both statements carefully and select the correct option.
Assertion (A): The Levinson-Durbin algorithm is used to solve the LPC equations in the Autocorrelation method.
Reason (R): The Autocorrelation matrix has a Toeplitz structure, which enables the efficient recursive computation of predictor coefficients.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2018

192. Which set of parameters derived from LPC analysis ensures a stable all-pole filter if their magnitudes are strictly less than 1?
(A) Predictor coefficients (the standard a-parameters)
(B) Log-area ratios (LARs)
(C) Reflection coefficients (k-parameters)
(D) Line spectral frequencies (LSFs)

2021

193. The residual signal from LPC analysis of a voiced speech frame contains prominent spikes. What do the time intervals between these spikes correspond to?
(A) Formant bandwidths and locations
(B) The fundamental pitch period
(C) The analysis window length parameter
(D) The frame shift duration interval

2012

194. In the context of speech recognition lexicons, homophones present a challenge because they:
(A) Have identical spellings but different pronunciations
(B) Do not exist in standard speech recognition acoustic models
(C) Cannot be modeled effectively by standard hidden Markov models
(D) Have different spellings but identical pronunciations

2007

195. Dynamic Time Warping (DTW) calculates distance on a grid. If the reference template length is N and test length is M, what is the computational complexity of standard DTW?
(A) $O(N+M)$
(B) $O(N \times M)$
(C) $O(\max(N, M))$
(D) $O(N^M)$

2002

196. Consider the following statements about continuous speech recognition using Hidden Markov Models (HMMs):
I. A triphone model accounts for coarticulation by considering the left and right phonetic context.
II. Monophone models are generally more accurate than triphone models for large vocabulary tasks.
III. State tying (e.g., using decision trees) is used to reduce the number of parameters in triphone modeling.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2001

197. Which feature compensation technique addresses additive noise by estimating the noise spectrum during silent intervals and removing it from the speech frames?
(A) Spectral Subtraction
(B) Cepstral Mean Subtraction
(C) Vocal Tract Length Normalization
(D) Linear Predictive Coding

2024

198. The musical noise phenomenon in spectral subtraction can be visually identified on a spectrogram as:
(A) Thick vertical black bars
(B) Smooth, blurred formants
(C) Continuous horizontal lines running across all frequency ranges
(D) Random, isolated dark spots (islands of

Click Here to Buy book on Flipkart

filters
(C) Uniformly spaced frequency domain comb filters
(D) Non-uniformly spaced auditory bandpass filters

2014
130. When quantizing a speech signal, the signal-to-quantization-noise ratio (SQNR) for a uniform quantizer increases by approximately how much for each additional bit of resolution?
(A) 3 dB
(B) 6 dB
(C) 10 dB
(D) 12 dB

2012
131. In Delta Modulation, increasing the sampling rate has which direct effect on system performance?
(A) It strictly increases the internal granular noise level
(B) It reduces slope overload distortion for a given step size
(C) It completely removes any requirement for a signal predictor
(D) It directly alters the fundamental frequency of voiced speech

2024
132. The primary objective of Adaptive Differential Pulse Code Modulation (ADPCM) over DPCM is to:
(A) Completely eliminate all quantization noise
(B) Code speech directly into spectral parameters
(C) Compress the time axis of the speech signal
(D) Accommodate non-stationarity of speech

2001
133. Consider the following statements about parametric vocoders:
I. They model the speech production mechanism directly.
II. They transmit the precise time-domain error residual.
III. They struggle to reproduce high-quality natural-sounding speech compared to waveform coders.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2004
134. Short-time analysis of speech assumes that over a sufficiently short interval (typically 10-30 ms), the speech signal is approximately:
(A) Ergodic
(B) Deterministic
(C) Stationary
(D) Uncorrelated

2024
135. The choice of window function in STFT is a trade-off between main-lobe width and side-lobe level. Which of the following provides the narrowest main lobe?
(A) Rectangular window
(B) Standard Hamming window
(C) Standard Hanning window
(D) Standard Blackman window

2022
136. In interpreting spectrograms, silent gaps followed by a sudden burst of broadband energy across a wide frequency range clearly indicate which phonetic class?
(A) Vowels
(B) Nasals
(C) Plosives
(D) Fricatives

2021
137. Which mathematical sequence forms the core of computing the complex cepstrum of a sequence $x(n)$?
(A) Fourier Transform $\rightarrow$ Complex Logarithm $\rightarrow$ Inverse Fourier Transform
(B) Fourier Transform $\rightarrow$ Complex Exponentiation $\rightarrow$ Inverse Fourier Transform
(C) Autocorrelation matrix $\rightarrow$ Fourier Transform $\rightarrow$ Complex Logarithm
(D) Z-transform $\rightarrow$ Logarithm $\rightarrow$ Inverse Z-transform

NODIA

2023
138. The extraction of Mel-Frequency Cepstral Coefficients (MFCCs) deliberately discards which information from the original speech signal?
(A) Phase information
(B) Magnitude spectrum envelope
(C) Formant locations
(D) Energy levels

2009
139. In the Linear Predictive Coding (LPC) all-pole model, the transfer function $H(z)$ is given by

(B) By transmitting an alternating sequence of 1s and 0s
(C) By transmitting a continuous sequence of all 0s
(D) By completely ceasing transmission until the signal changes

2022
210. Differential Pulse Code Modulation (DPCM) achieves bit-rate reduction by directly quantizing the:
(A) Instantaneous amplitude of the original uncompressed speech signal
(B) First-order mathematical derivative of the incoming speech signal
(C) Instantaneous phase angle of the multi-frequency speech signal
(D) Difference between the sample and its prediction

2022
211. Code-Excited Linear Prediction (CELP) minimizes the error between the original and synthesized speech using a perceptually weighted error criterion. This weighting is applied to:
(A) Emphasize errors in the formant valleys where noise is more audible
(B) Emphasize errors at the formant peaks where signal energy is highest
(C) Filter out the fundamental frequency entirely
(D) Flatten the overall speech spectrum completely

2025
212. Match the speech processing window and filtering characteristics in List I with their primary benefits or drawbacks in List II:
List I: (Speech Processing Characteristics)
P. Rectangular Window
Q. Hamming Window
R. Frame Overlapping
S. Pre-emphasis
List II: (Benefits or Drawbacks)
1. High spectral leakage
2. Boosts high-frequency components
3. Reduces spectral leakage at frame edges
4. Prevents data loss due to window edge tapering
Select the correct option:
(A) P-3, Q-1, R-2, S-4
(B) P-4, Q-2, R-1, S-3
(C) P-1, Q-3, R-4, S-2
(D) P-1, Q-4, R-3, S-2

NODIA

2005
213. When analyzing the STFT of a non-stationary signal like speech, reducing the window length N leads to:
(A) Better time resolution, poorer frequency resolution
(B) Better frequency resolution, poorer time resolution
(C) Better time and frequency resolution
(D) No change in either resolution

2006
214. A wideband spectrogram is characterized by:
(A) High frequency resolution and poor time resolution
(B) Distinct horizontal lines marking individual harmonics
(C) A very long analysis window (e.g., 30 ms or more)
(D) Poor frequency resolution and high time resolution

2008
215. The complex cepstrum of a sequence is defined using the complex logarithm. This requires the phase of the Fourier transform to be:
(A) Strictly positive and real-valued
(B) Continuous and unwrapped
(C) Uniformly quantized to 8 bits
(D) Set entirely to zero across all bins

2011
216. Mel-Frequency Cepstral Coefficients (MFCCs) use a filter bank to sum the energy within specific frequency bands. This operation mimics which aspect of human hearing?
(A) Phase sensitivity and phase alignment
(B) Pitch synchronous harmonic detection
(C) Critical band energy integration
(D) Binaural spatial source localization

2025
217. The Linear Predictive Coding (LPC) all-pole model mathematically struggles to accurately model which specific phonetic class?
(A) Monophthong Vowels
(B) Diphthongs
(C) Approximants
(D) Nasal consonants

2025
218. In the Autocorrelation method of LPC, the resulting set of linear equations forms a Toeplitz matrix. What specific mathematical property defines a Toeplitz matrix?
(A) All elements on any given diagonal are

identical
(B) It is strictly diagonal with non-zero elements
(C) The matrix determinant is guaranteed to be exactly zero
(D) It is a perfectly orthogonal and symmetric matrix

2008

219. Consider the following statements about the Levinson-Durbin algorithm in Linear Predictive Coding (LPC):
I. It computes the predictor coefficients iteratively, starting from order 1 up to p.
II. It requires the computation of reflection coefficients at each step.
III. It solves the normal equations generated by the Covariance method.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2012

220. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Read both statements carefully and select the correct option.
Assertion (A): Formant frequencies can be estimated directly by finding the roots of the LPC predictor polynomial $A(z)$.
Reason (R): The roots of $A(z)$ correspond to the poles of the vocal tract transfer function, which represent the resonant frequencies.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2008

221. Language modeling in a speech recognition system typically relies on N-gram statistics. A bi-gram model predicts the probability of a word based on:
(A) The immediately preceding word
(B) The complete grammatical syntax of the sentence
(C) The two preceding words
(D) The acoustic features of the word

2004

222. In Dynamic Time Warping (DTW), the starting and ending points of the warping path are usually constrained to align the first frame of the test signal with the first frame of the reference, and similarly for the last frames. This is known as:
(A) Monotonicity constraint
(B) Local continuity constraint
(C) Endpoint constraint
(D) Windowing constraint

2007

223. The Baum-Welch algorithm is used in HMM-based speech recognition systems primarily for:
(A) Decoding the most likely sequence of hidden states
(B) Extracting robust MFCC features from the speech waveform
(C) Performing real-time cepstral mean subtraction normalization
(D) Training the emission and transition probabilities

2012

224. Which of the following statements best describes the effect of Cepstral Mean Subtraction (CMS) on the original speech signal?
(A) It completely eliminates all stationary and non-stationary additive background noise
(B) It dynamically modifies the fundamental frequency of the speaker to a normalized value
(C) It high-pass filters the temporal trajectory of cepstral coefficients
(D) It significantly compresses the dynamic range of the time-domain acoustic waveform

2023

225. The oversubtraction factor in spectral subtraction algorithms is typically adjusted dynamically based on which parameter?
(A) The speaker's gender and vocal tract length parameters
(B) The a posteriori Signal-to-Noise Ratio (SNR) of the current frame
(C) The physical sampling rate of the input digitized speech audio file
(D) The overall number of extracted static MFCC coefficients

2010

226. In deriving the Wiener filter for speech enhancement, the cross-correlation between the clean speech and the noise is assumed to be:
(A) Equal to the signal variance
(B) Exactly 1
(C) Negative
(D) Zero

Downloaded from www.pdf.tube

2024

227. Pitch-synchronous overlap-and-add (PSOLA) is a powerful technique primarily used in speech processing for:
(A) Modifying the pitch and duration of speech
(B) Removing reverberation from enclosed spaces
(C) Extracting exactly 13 MFCC coefficients
(D) Encrypting voice data for secure transmission

2006

228. Comb filters can be implemented digitally using a delay line. If the fundamental frequency of a speech signal is 200 Hz and the sampling rate is 8 kHz, what is the required delay in samples to align the peaks of the comb filter with the harmonics?
(A) 20 samples
(B) 40 samples
(C) 100 samples
(D) 200 samples

2001

229. Which mathematical theorem dictates that reconstructing a continuous signal perfectly from its samples requires interpolation with a sinc function?
(A) Nyquist-Shannon Sampling Theorem
(B) Parseval's Energy Conservation Theorem
(C) Wiener-Khinchin Power Spectral Theorem
(D) Cramer-Rao Lower Variance Bound

2002

230. Match the speech features in List I with their corresponding phonetic units in List II:
List I: (Speech Features)
P. F2 locus transition
Q. Burst frequency
R. Anti-resonances (zeros)
S. High-frequency continuous noise
List II: (Phonetic Units)
1. Plosive release
2. Nasal consonants
3. Unvoiced Fricative
4. Place of articulation in stops
Select the correct option:
(A) P-1, Q-4, R-3, S-2
(B) P-4, Q-2, R-1, S-3
(C) P-2, Q-3, R-1, S-4
(D) P-4, Q-1, R-2, S-3

2001

231. The vocal tract length of an average adult male is approximately 17 cm. This biological constraint directly explains why male voices generally have:
(A) A higher fundamental frequency than female voices
(B) Lower average formant frequencies than female voices
(C) A lower fundamental frequency than female voices
(D) Higher average formant frequencies than female voices

NODIA

2003

232. Consider the following statements regarding the characteristics of a speech signal:
I. It is fundamentally non-stationary over long durations.
II. It contains quasi-periodic segments.
III. It contains noise-like aperiodic segments.
IV. Its energy distribution is uniform across all frequencies.
Which of the above statements are correct?
(A) I, II and IV
(B) I, II and III
(C) II, III and IV
(D) I, III and IV

2025

233. The human perception of loudness is frequency-dependent. Which standardized contours describe the sound pressure level required at different frequencies to sound equally loud as a 1 kHz reference tone?
(A) Critical Band resolution contours
(B) Mel-scale frequency mappings
(C) Bark scale auditory functions
(D) Equal-Loudness contours

2007

234. When an analog speech signal is digitized, increasing the sampling rate beyond twice the maximum frequency present in the signal (oversampling) provides which practical benefit?
(A) It reduces the required precision of the anti-aliasing filter
(B) It completely eliminates any need for subsequent quantization
(C) It completely and permanently removes all background noise
(D) It inherently and significantly compresses the transmission bit rate

2006

235. In μ-law companding, the formula uses a logarithmic curve. When the input signal x is small, the amplification provided by the compander is:
(A) Mathematically zero
(B) Very large, providing high gain

ANSWERS

1. (D) Vocal cords
Voiced speech sounds are produced when the vocal cords, located in the larynx, undergo periodic vibration. The lungs force airflow upward through the glottis, causing the vocal folds to open and close rapidly. This physical mechanism chops the continuous airstream into periodic air pulses, which serve as the primary acoustic source for voiced speech in humans.

2. (C) Aperiodic broadband noise source
Unvoiced fricative sounds are produced by forcing air through a narrow constriction in the vocal tract. This turbulent airflow generates a highly aperiodic, random, and broadband acoustic noise source. Unlike voiced sounds, there is no glottal vibration, resulting in a spectrum characterized by continuous high-frequency noise components rather than any distinct harmonic structures or stable formant patterns.

3. (B) The rate of vocal fold vibration
In the source-filter framework, the fundamental frequency represents the rate at which the vocal folds vibrate during voiced speech production. This rate of glottal opening and closing defines the pitch of the speaker. It serves as the primary periodic excitation source, which is subsequently shaped by the resonance characteristics of the vocal tract filter.

4. (D) Simultaneous masking
Simultaneous masking occurs when the auditory system is exposed to a loud sound and a quieter sound at the same time. The stronger sound raises the hearing threshold of the ear within a specific frequency band, rendering the weaker, adjacent acoustic signal completely inaudible. This psychoacoustic behavior is a key principle utilized in digital audio compression algorithms.

5. (C) 8 kHz
The Nyquist-Shannon sampling theorem states that to prevent aliasing, a continuous signal must be sampled at a rate greater than twice its highest frequency component. For a speech signal containing a maximum frequency of four kilohertz, the minimum sampling rate required to guarantee perfect reconstruction and avoid spectral overlap is exactly eight kilohertz.

6. (C) They maintain a constant signal-to-quantization noise ratio
Speech signals contain a wide dynamic range, with low-amplitude segments occurring far more frequently than high-amplitude ones. Non-uniform quantization schemes like A-law and mu-law companding use logarithmic step sizes. This logarithmic compression ensures that smaller signals receive finer quantization steps, which maintains a relatively constant signal-to-quantization noise ratio across various input power levels.

7. (A) When the input signal changes faster than the step size can track
Slope overload distortion in delta modulation systems happens when the analog input signal has a high rate of change. If the slope of the signal exceeds the maximum tracking capability of the feedback loop, the fixed-step escalator cannot keep pace. The modulator output fails to match the fast-changing signal, introducing significant reconstruction error.

8. (D) By dynamically adapting the quantization step size based on signal variance
Adaptive Differential Pulse Code Modulation enhances standard predictive coding by dynamically adjusting the quantization step size according to the local variance of the prediction error. Over fast-changing regions, the step size increases to prevent slope overload, while in quiet regions, it decreases to minimize granular noise. This dynamic adaptation yields superior coding efficiency.

9. (B) It provides excitation vectors to model the residual signal
In Code-Excited Linear Prediction, the excitation signal is modeled using index-based codebooks containing pre-defined stochastic and adaptive vectors. Instead of transmitting the entire prediction residual, the encoder searches these codebooks to find the optimal vector that minimizes perceptual error, transmitting

Click Here to Buy book on Amazon

2024
245. In the Covariance method of LPC analysis, the total squared error is minimized over:
(A) A finite, unwindowed interval of the speech signal
(B) An infinite interval $[-\infty, \infty]$
(C) A finite, windowed interval spanning exactly three successive frames
(D) Only the first 10 samples of the frame

2016
246. The Levinson-Durbin recursion relies on the fact that the autocorrelation sequence $R(k)$ satisfies which property?
(A) $R(k) = -R(-k)$
(B) $R(k) = 0$ for all $k > 0$
(C) $R(k) = 1$ for all k
(D) $R(k) = R(-k)$

2009
247. When the roots of the LPC predictor polynomial $A(z)$ are plotted on the complex z-plane, formants are generally indicated by:
(A) Roots that are positioned strictly on the negative real axis
(B) Complex conjugate roots lying close to the unit circle
(C) Roots located exactly and precisely at the z-plane origin
(D) Roots lying far outside the boundary of the unit circle

2002
248. In HMM-based speech recognition, a "triphone" represents a phoneme in the context of its immediate left and right neighbors. How many logically possible triphones exist for a language with 40 distinct phonemes?
(A) 40
(B) 120
(C) 1600
(D) 64000

2013
249. During the decoding phase of a continuous speech recognition system, the Viterbi algorithm effectively performs which search operation?
(A) Exhaustive mathematical search across all possible acoustic word sequences
(B) Random probability walk through the allowed state transitions
(C) Linear lookup search of the entire vocabulary lexicon
(D) Dynamic programming search to find the most likely state sequence

2016
250. Which mathematical criterion does the Expectation-Maximization (EM) algorithm optimize during HMM training?
(A) Maximum Likelihood (ML)
(B) Minimum Mean Square Error (MMSE)
(C) Signal-to-Noise Ratio (SNR)
(D) It minimizes the cross-entropy directly

2022
251. RASTA filtering aims to suppress slowly varying convolutional noise. To achieve this, it applies a band-pass filter to the time trajectories of which parameters?
(A) The raw continuous time-domain speech samples
(B) The log spectral or cepstral coefficients
(C) The raw high-resolution magnitude spectrum
(D) The estimated fundamental pitch period values

2006
252. Consider the following statements regarding spectral subtraction in speech enhancement:
I. It assumes noise is additive and uncorrelated with the speech signal.
II. It requires an accurate estimate of the noise power spectrum.
III. It modifies the phase of the noisy speech signal to enhance quality.
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2016
253. The "musical noise" generated by spectral subtraction consists of random, short-duration tones. What is the fundamental cause of these tones?
(A) Statistical variance in noise estimates leading to unsubtracted spectral peaks
(B) Incorrect mathematical estimation of the speaker's true fundamental pitch frequency
(C) The suboptimal use of a Hanning window instead of a standard Hamming window
(D) Severe aliasing distortion occurring in the digital-to-analog converter

2016
254. In Wiener filtering applied to speech enhancement, the filter is often formulated as $H(\omega) = \dfrac{P_s(\omega)}{P_s(\omega) + P_n(\omega)}$. What does $P_s(\omega)$ represent?

NODIA

evaluate how well acoustic features fit phonetic states, the language model determines which word sequences make logical sense, drastically improving decoding accuracy in complex continuous speech.

20. (A) P-2, Q-1, R-4, S-3
Autocorrelation is a key tool in pitch extraction and linear predictive analysis. Dynamic Time Warping aligns two temporal sequences of varying lengths non-linearly. The spectrogram is a fundamental three-dimensional representation illustrating signal energy across time and frequency. Companding is a non-uniform quantization technique designed to optimize speech signal transmission over digital channels.

21. (A) Gaussian Mixture Model (GMM)
In traditional speech recognition engines, Gaussian Mixture Models are used to represent the continuous probability density function of acoustic features within each hidden state. A GMM combines multiple multidimensional Gaussian components, allowing it to accurately model the complex, multi-modal variations found in speech feature vectors extracted from different speakers and acoustic environments.

22. (C) Cepstral Mean Subtraction (CMS)
Cepstral Mean Subtraction is an effective, low-complexity feature normalization technique designed to mitigate the effects of channel distortion and stationary noise. By calculating the average value of each cepstral coefficient across an entire utterance and subtracting it from each frame, CMS effectively cancels out linear convolutional channel effects in the log-spectral domain.

23. (A) Residual noise peaks left after spectral subtraction
Musical noise is a common artifact of spectral subtraction algorithms caused by the random, fluctuating nature of the short-time noise spectrum. When subtracting the average noise estimate, isolated spectral peaks remain scattered randomly across frames. In the reconstructed time-domain signal, these remaining noise peaks sound like artificial, short-lived sinusoidal tones resembling music.

24. (D) Mean Square Error of the estimated and clean speech signals
Wiener filtering is a classic speech enhancement technique designed to suppress additive background noise. The filter is mathematically derived to minimize the mean square error between the target clean speech signal and the estimated clean speech. It achieves optimal noise reduction by attenuating frequency bins containing low signal-to-noise ratios while preserving high-energy speech components.

25. (B) Comb filtering
Comb filtering is highly effective for enhancing voiced speech because it exploits the periodic, harmonic nature of the glottal source. By setting the filter delays to correspond exactly with the fundamental pitch period, the comb filter acts to amplify the harmonic peaks while attenuating the inter-harmonic spectral regions where broadband background noise is concentrated.

26. (C) Velum (soft palate)
The velum, or soft palate, operates as a physiological valve that controls airflow between the oral and nasal cavities. During the production of non-nasal sounds, the velum is elevated to seal against the pharyngeal wall, blocking the nasal passage. This forces the lung air to exit exclusively through the mouth to create oral sounds.

27. (D) Unvoiced plosives (stops)
The phonemes /p/, /t/, and /k/ are classified as unvoiced plosives or stop consonants. Their articulation involves a complete closure of the vocal tract to build up air pressure, followed by a sudden explosive release. Because there is no vocal fold vibration during this pressure buildup phase, these sounds are characterized as unvoiced.

28. (A) An all-pole IIR filter
In the source-filter theory, the vocal tract during vowel production is represented mathematically as an all-pole infinite impulse response filter. This modeling choice is highly accurate because non-nasalized vowels are characterized primarily by acoustic resonances, or formants, which correspond directly to the poles of the transfer function in the complex frequency plane.

Downloaded from www.pdf.tube

2018

265. What is the primary role of the pitch filter (long-term predictor) in a CELP vocoder?
(A) To model the dynamic resonances of the human vocal tract
(B) To synthesize high-frequency random unvoiced noise components
(C) To apply non-linear A-law or mu-law companding characteristics
(D) To remove the fine harmonic structure from the residual

2005

266. Frame blocking creates segments of speech that are typically 20-30 ms long. The frame shift (or hop size) is usually chosen to be:
(A) About 10 ms (resulting in 50-67% overlap)
(B) Equal to the analysis frame size with no overlap
(C) Exactly 1 ms for all continuous applications
(D) Twice the analysis frame size introducing gaps

2025

267. When computing the STFT, applying a window function is equivalent to doing what to the signal's infinite Fourier Transform?
(A) Adding it to the window's Fourier Transform
(B) Convolving it with the window's Fourier Transform
(C) Multiplying it directly by the window's calculated Fourier Transform
(D) Differentiating it

2002

268. Consider the following statements regarding spectrographic analysis of speech:
I. Formants appear as dark frequency bands in wideband spectrograms.
II. Pitch variations can be tracked using the horizontal striations in narrowband spectrograms.
III. Fricatives display intense energy concentrated at very low frequencies (below 500 Hz).
Which of the above statements are correct?
(A) I and II
(B) I and III
(C) II and III
(D) I, II and III

2014

269. The liftering process in homomorphic speech analysis involves applying a window in the cepstral domain. To isolate the smoothed vocal tract spectral envelope, one must retain:
(A) Only the low-quefrency components
(B) Only the high-quefrency components
(C) Only the peak representing the pitch period
(D) The entire complex cepstrum unchanged

2002

270. Why is the logarithm function pivotal in computing Mel-Frequency Cepral Coefficients (MFCCs)?
(A) It converts the linear frequency scale to the Mel scale directly
(B) It completely eliminates any need for the Fast Fourier Transform
(C) It transforms multiplicative components into additive ones
(D) It explicitly and perfectly normalizes the overall phase spectrum

****

NODIA

(C) Highly linear and extremely minimal
(D) Logarithmic and asymptotically maximal

2009

236. Granular noise in Delta Modulation is most severe during which phase of the input speech signal?
(A) During extremely rapid and sudden acoustic amplitude transitions
(B) During silent or relatively constant amplitude intervals
(C) During the dynamic onset phase of unvoiced fricatives
(D) During the explosive burst release phase of plosives

2015

237. The prediction gain in a DPCM system is defined as the ratio of:
(A) The signal variance to the prediction error variance
(B) The peak acoustic signal amplitude to the minimum step size
(C) The physical sampling frequency to the minimum Nyquist frequency
(D) The total predictor filter order to the analysis frame size

2022

238. In Analysis-by-Synthesis speech coders (like CELP), the "Synthesis" part implies that the encoder contains an internal:
(A) HMM state decoder to estimate the most likely phone sequence
(B) High-resolution Analog-to-Digital Converter system
(C) Model of the vocal tract to test excitation vectors
(D) Mel-frequency scale filter bank for spectral analysis

2021

239. The process of pre-emphasis in speech processing typically applies a first-order FIR filter of the form $H(z) = 1 - \alpha z^{-1}$. A typical value for α is:
(A) 0.10
(B) 0.50
(C) 0.95
(D) 1.50

2005

240. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Read both statements carefully and select the correct option.
Assertion (A): The Discrete Cosine Transform (DCT) is applied to the log filter-bank energies to compute MFCCs.
Reason (R): The DCT acts to decorrelate the highly correlated filter-bank energies, producing roughly independent coefficients.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2012

241. If a Hamming window is applied to a 20 ms speech frame, the signal values exactly at the boundaries (start and end) of the window are:
(A) Multiplied by a factor of exactly zero
(B) Multiplied by a small non-zero value (approx. 0.08)
(C) Multiplied by a constant factor of exactly positive one
(D) Multiplied by a constant factor of exactly negative one

2025

242. In a narrowband spectrogram of a male speaker with a fundamental frequency of 100 Hz, the horizontal striations (harmonics) will be spaced apart by approximately:
(A) 50 Hz
(B) 100 Hz
(C) 1000 Hz
(D) 3400 Hz

2018

243. The complex cepstrum of a minimum-phase signal has which unique property?
(A) It is zero for all negative quefrencies
(B) It is perfectly symmetric around zero
(C) It is strictly a complex sequence
(D) It only contains impulses at the fundamental frequency

2025

244. The fundamental assumption of LPC is that the speech production process can be modeled as a linear system. Which component represents the input (driving function) to this system for a voiced vowel?
(A) Continuous white Gaussian noise excitation
(B) A single pure sinusoidal frequency wave
(C) A quasi-periodic glottal pulse train
(D) The output synthesized speech signal itself

Click Here to Buy book on Flipkart

only the selected index and gain parameters to reconstruct the speech excitation.

10. (A) Both A and R are true and R is the correct explanation of A.
Short-time speech analysis requires segmenting continuous signals into discrete frames, which creates artificial discontinuities at the edges. A rectangular window truncates the signal abruptly, leading to severe spectral leakage in the frequency domain. Applying a tapered Hamming window smoothly attenuates the signal at frame boundaries, thereby reducing these edge discontinuities and minimizing spectral leakage.

11. (D) A longer window provides better frequency resolution but poorer time resolution
The Short-Time Fourier Transform is governed by the uncertainty principle, imposing a strict trade-off between time and frequency resolution. A longer analysis window captures more signal cycles, leading to high-precision frequency resolution, but smears the timing of transient acoustic events. Conversely, shorter windows offer sharp temporal localization at the expense of resolving individual spectral harmonics.

12. (A) Vertical striations indicating glottal pulses
A wideband spectrogram utilizes a short window in the time domain, which yields high temporal resolution but poor frequency resolution. This fine time resolution allows the individual glottal pulses to be clearly resolved as vertical striations along the time axis. In contrast, a narrowband spectrogram uses longer windows, which resolve individual horizontal harmonic lines instead.

13. (B) Cepstral domain
Homomorphic speech processing decompresses the convoluted relationship between the vocal tract filter and glottal excitation. By taking the logarithm of the magnitude spectrum and applying the inverse Fourier transform, the convolution operation is converted into simple addition. In this resulting cepstral domain, low-quefrency components represent the filter, while high-quefrency peaks isolate the periodic source.

14. (B) Mel-scale filter bank mapping
The human ear processes frequencies non-linearly, showing higher sensitivity below one kilohertz and logarithmic perception at higher ranges. During the extraction of cepstral coefficients, this psychoacoustic behavior is modeled by passing the power spectrum through a bandpass filter bank spaced linearly along the Mel-scale, transforming physical frequencies into perceptually warped representations.

15. (A) Past speech samples
Linear Predictive Coding is based on the mathematical assumption that a given speech sample can be estimated as a linear combination of a finite number of previous speech samples. This digital model represents the vocal tract as a simple all-pole digital filter, where the feedback coefficients capture the resonant formants from the historical time-series data.

16. (C) The autocorrelation formulation of the windowed signal guarantees that all poles lie inside the unit circle
The autocorrelation method of linear prediction applies a window function to truncate the speech frame to zero outside the analysis interval. Formulating the prediction equations through this windowed signal yields a Toeplitz matrix. Solving this system mathematically guarantees that the poles of the estimated digital filter strictly lie within the unit circle, ensuring filter stability.

17. (D) Toeplitz symmetry
The Levinson-Durbin algorithm is an exceptionally fast recursive technique used to solve the Yule-Walker equations in linear prediction. It dramatically reduces computational complexity from cubic to quadratic time. This efficiency is achieved by directly exploiting the Toeplitz symmetry of the autocorrelation matrix, where all elements along any diagonal are completely identical.

18. (C) The excitation source residual signal
An LPC analysis filter acts as an inverse filter that removes the spectral envelope shaped by the vocal tract resonances. When a speech waveform is passed through this inverse filter, the formants are flattened out. The remaining output is the prediction error, which closely represents the original glottal excitation source residual signal.

19. (B) To estimate the prior probability of a sequence of words occurring
A language model provides syntactic and grammatical constraints to a speech recognition system by estimating the prior probability of a specific sequence of words. While acoustic models

Downloaded from www.pdf.tube

(A) Power spectrum of the noise
(B) Power spectrum of the observed noisy speech
(C) Power spectrum of the clean speech
(D) Phase spectrum of the clean speech

2012
255. Pitch-synchronous analysis methods require epoch extraction. An epoch in voiced speech physically corresponds to:
(A) The instant of maximum glottal opening
(B) The midpoint of the vowel duration
(C) The peak of the first formant resonance
(D) The instant of sudden glottal closure

2017
256. A comb filter for harmonic enhancement is designed using a delay line. If the fundamental frequency of the speaker suddenly doubles, what must happen to the delay length in the comb filter for optimal enhancement?
(A) The delay length must be doubled
(B) The delay length must remain unchanged
(C) The delay length must be halved
(D) The delay length must be squared

2013
257. Which articulatory feature distinguishes the phonetic production of /s/ from /z/?
(A) Place of articulation
(B) Voicing
(C) Manner of articulation
(D) Nasality

2018
258. In the source-filter model, the glottal volume velocity waveform for voiced speech has a spectral roll-off of approximately:
(A) -18 dB/octave
(B) -12 dB/octave
(C) -6 dB/octave
(D) 0 dB/octave (flat)

2010
259. Simultaneous auditory masking is most pronounced when the masker and the target signal are:
(A) Within the same critical band
(B) Separated by several physical octaves
(C) Simultaneously presented to different ears
(D) Produced as completely unvoiced sounds

2025
260. The following question consists of two statements, one labeled as Assertion (A) and the other as Reason (R). Read both statements carefully and select the correct option.

Assertion (A): The phase spectrum is typically ignored in standard speech recognition feature extraction.
Reason (R): The human auditory system is largely insensitive to the absolute phase of the speech signal.
(A) Both (A) and (R) are true and (R) is the correct explanation of (A).
(B) Both (A) and (R) are true but (R) is NOT the correct explanation of (A).
(C) (A) is true but (R) is false.
(D) (A) is false but (R) is true.

2006
261. In the context of quantization, the clipping threshold defines the maximum allowable input amplitude. Exceeding this threshold results in:
(A) Overload distortion (clipping)
(B) High-frequency granular noise
(C) High-frequency spectral aliasing
(D) Severe mathematical slope overload

2018
262. Delta Modulation acts inherently as what type of analog-to-digital predictor?
(A) A zero-order predictor that simply uses the previous sample directly
(B) A tenth-order high-precision linear predictive coding predictor
(C) A non-linear Gaussian Mixture Model statistical predictor
(D) A first-order predictor using the previously reconstructed sample value

NODIA

2025
263. DPCM codes the prediction error instead of the raw sample. If the predictor is perfect, the theoretical variance of the error signal would be:
(A) Infinite
(B) Zero
(C) Equal to the signal variance
(D) One

2016
264. In ADPCM, backwards adaptation of the quantizer step size implies that the step size is updated using:
(A) The unquantized original input signal samples
(B) Look-ahead temporal buffers of future speech samples
(C) Only the previously quantized error values
(D) The estimated pitch frequency of the current analysis frame

29. (B) I and III
The basilar membrane in the cochlea acts as a non-uniform bandpass filter bank, with high frequencies exciting the base and low frequencies resonating near the apex. The bandwidths of these auditory filters, known as critical bands, are narrow at lower frequencies and become progressively wider as the center frequency of the band increases.

30. (B) An ideal brick-wall low-pass filter
Sampling a continuous signal at exactly the Nyquist rate creates infinite adjacent spectral copies that touch without overlapping. To perfectly reconstruct the original analog speech signal from these discrete samples, an ideal brick-wall low-pass reconstruction filter is theoretically required. This filter completely passes the baseband signal while blocking all high-frequency modulation images.

31. (A) Noise occurring when the input signal is relatively constant
Granular noise in delta modulation systems is an inherent quantization artifact that occurs when the input signal remains relatively flat or changes slowly. Under these conditions, the fixed step size of the modulator is too large, causing the reconstructed signal to oscillate continuously above and below the true analog input, generating a high-frequency background buzz.

32. (C) Quantizing the difference of current and predicted samples
Differential Pulse Code Modulation exploits the high temporal correlation present in adjacent speech samples. Instead of directly quantizing the absolute amplitude of each sample, DPCM calculates a predicted value based on past history and quantizes only the resulting prediction error. This difference signal has lower variance, allowing higher coding efficiency.

33. (D) Transmitted pitch, voicing status, and vocal tract parameters
Parametric vocoders synthesize speech at the receiver by applying speech parameters to a model of human speech production. The system does not transmit the actual acoustic waveform. Instead, it utilizes transmitted parameters containing the fundamental frequency, voicing state, and vocal tract filter coefficients to drive a digital excitation source through a synthesis filter.

34. (C) To flatten the spectral envelope by boosting high frequencies
Speech signals inherently exhibit a spectral tilt, where higher frequencies are naturally attenuated at a rate of six to twelve decibels per octave. Applying a pre-emphasis high-pass filter boosts these weaker high-frequency components. This flattens the spectral envelope, balancing the signal energy across the entire spectrum for better analysis.

35. (A) III, II, I, IV
The Short-Time Fourier Transform process begins by segmenting the continuous analog speech signal into short, overlapping time frames. Next, each individual frame is multiplied by a window function to reduce spectral leakage. The Discrete Fourier Transform is then computed for each windowed frame, after which the corresponding magnitude spectrum is calculated.

36. (B) First Formant (F1)
During vowel articulation, the vertical position or height of the tongue alters the cross-sectional area of the pharyngeal and oral cavities. This physical change in cavity volume directly dictates the resonance frequency of the first formant. A higher tongue position decreases the frequency of the first formant, while a lower tongue position increases it.

37. (A) To obtain a continuous phase curve for the complex logarithm
Computing the complex cepstrum requires taking the complex logarithm of the spectrum. Standard phase values are wrapped within a principal interval of minus π to π, introducing artificial step discontinuities. Phase unwrapping is necessary to reconstruct a smooth, continuous phase curve, ensuring the inverse Fourier transform yields a mathematically valid and stable cepstral representation.

38. (C) To decorrelate the log-filterbank energies
During Mel-Frequency Cepstral Coefficients extraction, the outputs of adjacent bandpass filters in the Mel-filter bank are highly correlated. The Discrete Cosine Transform is applied to these log-filter bank energies to decorrelate them. This energy compaction concentrates the key phonetic information into a few lower-

Click Here to Buy book on Amazon

order cepstral coefficients, which are ideal for statistical modeling.

39. (A) The linearly predicted value
In Linear Predictive Coding, the prediction error or residual signal is defined as the mathematical difference between the actual current speech sample and its predicted value. This predicted estimate is computed as a weighted linear combination of previous speech samples, where the weights correspond to the optimized predictor coefficients of the LPC model.

40. (C) A is true but R is false.
The Covariance method of linear prediction minimizes the prediction error over a finite, unwindowed interval, which does not guarantee that the resulting poles lie inside the unit circle. The assertion is true, but the reason is false because the covariance method explicitly avoids windowing the signal before minimizing the prediction error.

41. (B) LPC predictor and reflection coefficients
The Levinson-Durbin algorithm is an efficient recursive procedure used to solve the Yule-Walker equations. When applied to speech processing, its primary output is the set of linear prediction coefficients that model the vocal tract filter. It also calculates the corresponding reflection coefficients, which represent the physical boundaries inside an acoustic tube.

42. (C) Finding the roots of the predictor polynomial
Formant estimation using Linear Predictive Coding involves analyzing the all-pole filter transfer function. Since the formants correspond to the physical resonances of the vocal tract, their locations are determined by finding the complex roots of the predictor polynomial. The angles of these roots yield the center frequencies, while their radii determine formant bandwidths.

43. (B) I, II and IV
Dynamic Time Warping is a powerful dynamic programming algorithm used to align two temporal patterns that may vary in length and speaking rate. It computes an optimal alignment path between a test sequence and a reference template by minimizing cumulative distance. It does not require both sequences to have identical lengths to perform alignment.

44. (A) Finding the most likely sequence of hidden states
In speech recognition systems, the Viterbi algorithm is a dynamic programming method used for decoding. It processes an incoming sequence of acoustic feature vectors against a trained Hidden Markov Model to efficiently identify the single most probable sequence of hidden states. This state sequence maps directly to the recognized sequence of phonemes or words.

45. (B) It models the probability of acoustic features given phonetic states
The acoustic model is a core component of speech recognition systems that represents the statistical relationship between incoming acoustic feature vectors and phonetic units. It calculates the probability of observing a particular frame of speech features given a specific phoneme state, allowing the system to accurately map raw sounds onto their corresponding phonetic classifications.

NODIA

46. (B) To improve speech quality beyond magnitude-only methods
Traditional speech enhancement systems often focus solely on reconstructing the spectral magnitude while keeping the noisy phase unchanged. In highly degraded environments, this magnitude-only approach causes speech quality to suffer. Advanced systems use phase estimation techniques to reconstruct a cleaner phase spectrum, significantly reducing musical noise and enhancing the perceptual quality of the output speech.

47. (A) The power spectra are approximately additive
Standard spectral subtraction operates under the primary mathematical assumption that the power spectrum of a noisy speech signal is equal to the sum of the power spectra of clean speech and independent additive background noise. By estimating the average noise power during silent intervals, it is subtracted from the noisy spectrum to isolate the clean speech.

48. (C) A priori signal-to-noise ratio (SNR)
The design of an optimal Wiener filter for speech enhancement requires accurate estimation of the a priori signal-to-noise ratio across all frequency bins. This statistical parameter represents the ratio of clean speech power to noise power. Estimating the a priori SNR helps the filter

apply precise attenuation to noise-dominated regions while preserving clean speech.

49. (D) The periodic glottal closure instants
Pitch-synchronous processing techniques, such as PSOLA, analyze and synthesize speech by dividing the waveform into overlapping epochs centered on specific physiological events. These events are the glottal closure instants, which mark the periodic closing of the vocal folds. Aligning analysis frames with these points prevents phase distortion during pitch or duration modifications.

50. (B) I, IV and V
Comb filtering is a temporal enhancement technique that exploits the harmonic structure of voiced speech. By setting the filter delay to match the pitch period, it selectively preserves frequencies at the pitch harmonics while attenuating intermediate spectral regions. This successfully suppresses broadband background noise lying between the harmonics, improving the overall signal-to-noise ratio of voiced segments.

51. (B) Cricothyroid
The cricothyroid muscle is an intrinsic laryngeal muscle that plays a central role in speech production. By tilting the thyroid cartilage forward, it elongates and tenses the vocal cords. This increase in tension raises the rate of vocal fold vibration, thereby directly increasing the fundamental frequency, or pitch, of the voiced speech.

52. (D) Sustained harmonic resonance
Plosives are transient speech sounds characterized by a sequence of three distinct phases: a silent closure interval where air pressure builds up, a sudden burst of energy upon release, and a brief period of frication or aspiration. Unlike vowels, plosives are highly transient and completely lack a sustained harmonic resonance phase during their production.

53. (B) 500 Hz
A uniform vocal tract during neutral vowel production is modeled as a quarter-wavelength resonator tube closed at one end. The first formant frequency is calculated as the speed of sound divided by four times the tube length. Substituting three hundred forty meters per second and seventeen centimeters yields exactly five hundred hertz.

54. (C) Low-frequency sounds mask high-frequency sounds more effectively
The human auditory system exhibits a highly asymmetrical frequency masking behavior due to the mechanical properties of the basilar membrane. The excitation pattern of a low-frequency tone propagates along a larger portion of the membrane, creating a broad masking envelope that extends upward. Consequently, low-frequency sounds mask higher-frequency sounds far more effectively than vice-versa.

55. (A) $f_s \geq 2f_m$
To achieve perfect digitization without losing any information, the continuous signal must be sampled in compliance with the Nyquist theorem. This requires the sampling rate to be at least twice the maximum frequency present in the analog signal. If this mathematical condition is satisfied, the spectral copies do not overlap, completely avoiding aliasing distortion.

56. (D) Non-uniform quantization varies step size based on signal amplitude
In uniform quantization, the step size remains constant across all amplitude levels. In contrast, non-uniform quantization varies the quantization step size dynamically according to the signal amplitude. It utilizes smaller steps for low-amplitude signals and larger steps for high-amplitude signals, which is highly efficient for the logarithmic nature of human speech.

57. (A) P-2, Q-1, R-4, S-3
Pulse Code Modulation directly quantizes analog samples uniformly or non-uniformly. Delta Modulation represents changes between adjacent samples using a single-bit coder. Adaptive DPCM improves predictive coding by dynamically adjusting the quantization step size based on the prediction error. Linear Predictive Coding models speech by extracting and transmitting vocal tract filter and excitation parameters.

58. (C) Decreasing the step size
Granular noise occurs in delta modulation when the signal is relatively flat and the quantizer step size is too large, causing the system to hunt around the flat input. Decreasing the quantization step size allows the reconstructed waveform to track these low-amplitude regions with smaller oscillations, significantly minimizing the audible granular noise.

Downloaded from www.pdf.tube

59. (D) Through a closed-loop search minimizing perceptually weighted error
In Code-Excited Linear Prediction, the optimal excitation vector is selected using an analysis-by-synthesis loop. The encoder performs a closed-loop search through its codebooks, filtering candidate vectors through the pitch and envelope synthesis filters. It selects the vector that minimizes the perceptually weighted mean squared error between the original and synthesized speech frames.

60. (A) To compensate for window attenuation at frame boundaries
When dividing continuous speech into frames, window functions like the Hamming window are applied to taper the signal edges to zero, reducing spectral leakage. This windowing attenuates crucial signal information near the frame boundaries. Overlapping adjacent frames ensures that these attenuated boundary regions are fully captured in neighboring analysis frames during reconstruction.

61. (B) Heisenberg-Gabor principle
The resolution of a spectrogram is governed by the Heisenberg-Gabor uncertainty principle. This mathematical law dictates that one cannot achieve high resolution in both the time and frequency domains simultaneously. A narrower window improves temporal localization but broadens the spectral response, while a wider window provides excellent frequency resolution at the cost of temporal smearing.

62. (D) A false but R is true.
A narrowband spectrogram uses a long time window, which provides high frequency resolution. This allows the individual, closely spaced harmonics of the fundamental frequency to be resolved. However, because formants are wide-band envelope resonances, a wideband spectrogram with high temporal resolution is actually better suited for accurately tracing the broad formant bands.

63. (A) The fundamental pitch period
The complex cepstrum decomposes a speech signal into source and filter components. For voiced speech, the periodic vibration of the vocal folds creates a highly harmonic structure in the spectrum. In the cepstral domain, this periodic behavior manifests as a sharp, distinct peak at a specific quefrency index corresponding directly to the fundamental pitch period.

64. (B) Linear below 1 kHz, logarithmic above 1 kHz
The Mel-scale is a perceptual frequency scale designed to mimic human auditory pitch perception. It is characterized by a dual-regime mapping behavior. Below one kilohertz, the relationship between acoustic frequency and perceived pitch is approximately linear. Above one kilohertz, the scale shifts to a logarithmic mapping, reflecting the ear's reduced sensitivity to high-frequency variations.

65. (C) Resonances (formants) in vowels
The all-pole filter model used in Linear Predictive Coding is highly efficient at capturing the physical resonances of the vocal tract. During vowel production, these resonances, or formants, dominate the spectral envelope. Mathematically, these formants correspond directly to the complex conjugate poles of the transfer function, making LPC exceptionally suited for modeling vowel sounds.

66. (D) It is a Toeplitz matrix
In the autocorrelation method of linear prediction, computing the autocorrelation coefficients of a windowed frame yields a highly structured symmetric matrix. This matrix is a Toeplitz matrix, meaning all diagonal elements are identical. This unique mathematical property is highly advantageous, as it allows the system of equations to be solved rapidly using the Levinson-Durbin recursion.

67. (B) Between -1 and 1
In linear predictive analysis, reflection coefficients are calculated during the Levinson-Durbin recursive process. These coefficients represent the acoustic reflection properties of a modeled vocal tract tube. For the resulting all-pole digital synthesis filter to be stable, the magnitudes of all reflection coefficients must be strictly less than one, falling within the range of minus one to one.

68. (D) A sequence of impulses spaced by the pitch period
The LPC inverse filter removes the resonant formant characteristics shaped by the vocal tract envelope. For perfectly periodic voiced speech, the underlying excitation source is a series of glottal pulses. Consequently, the theoretical prediction error residual output of the inverse

NODIA

filter should resemble a clean sequence of unit impulses spaced precisely by the fundamental pitch period.

69. (A) I, IV, III, II
Building and running a standard HMM-based speech recognizer starts with feature extraction to convert the speech waveform into MFCCs. Next, acoustic models are trained to link these features to phoneme states. A language model is built to capture word transition probabilities. Finally, the decoding phase uses the Viterbi algorithm to identify the most likely word sequence.

70. (C) To prevent the warping path from reversing in time
Local path constraints in Dynamic Time Warping define the allowable step directions at each node along the grid. Their primary function is to enforce physical alignment rules, such as monotonicity and continuity. This prevents the warping path from reversing in time, ensuring that the alignment of the speech signals progresses sequentially from start to finish.

71. (A) Expectation-Maximization Algorithm
Gaussian Mixture Models are used to represent the continuous probability distribution of acoustic features. Because the true state assignments of these continuous features are hidden, direct maximum likelihood estimation cannot be performed. The Expectation-Maximization algorithm is conventionally used to iteratively estimate and refine the weights, means, and covariances of the individual Gaussian mixture components.

72. (B) I and IV
Cepstral Mean Subtraction and Cepstral Variance Normalization are highly effective feature compensation techniques designed to address channel distortions. Linear convolutional channel noise acts as an additive constant in the log-spectral cepstral domain. Subtracting the mean and normalizing the variance of the cepstral coefficients effectively minimizes these static channel effects, improving recognition robustness.

73. (B) To estimate noise during non-speech intervals
Spectral subtraction enhances noisy speech by subtracting the estimated noise spectrum from the input signal spectrum. To obtain an accurate noise profile, the algorithm relies on a Voice Activity Detector. The VAD identifies silence or non-speech intervals during which the algorithm can safely update and refine its estimate of the background noise power spectrum.

74. (D) Uncorrelated
The mathematical formulation of the classic Wiener filter for speech enhancement is derived under the fundamental statistical assumption that the target clean speech signal and the additive background noise are completely uncorrelated. This lack of correlation allows the power spectrum of the noisy signal to be modeled simply as the sum of their individual power spectra.

75. (D) Kept below the auditory masking threshold of the clean speech
Perceptual speech enhancement techniques leverage properties of the human auditory system. Instead of attempting to completely suppress all background noise, which often causes speech distortion, these algorithms estimate the masking threshold of the clean speech. The residual noise is then spectrally shaped to remain below this threshold, rendering it completely inaudible to the listener.

76. (A) Abduction and adduction of the vocal folds
The arytenoid cartilages are a pair of small, pyramid-shaped structures sitting on the cricoid cartilage in the larynx. They serve as the posterior attachment point for the vocal cords. The rotation and sliding movements of these cartilages are directly responsible for the abduction and adduction, or opening and closing, of the vocal folds during phonation.

77. (B) Plosive followed by a fricative
Affricates are complex consonant speech sounds characterized by a unique two-stage articulation process. Production begins with a complete closure of the vocal tract to build up air pressure, typical of a plosive stop consonant. Instead of an explosive release, the constriction is released slowly, creating a period of turbulent frication characteristic of a fricative.

78. (B) High-pass filter
The radiation of speech from the oral cavity into the surrounding free space is influenced by the physical boundary at the lips. This radiation characteristic behaves like a high-pass filter. It is typically approximated mathematically as a

Click Here to Buy book on Flipkart

differentiator, introducing a spectral boost of approximately six decibels per octave to the higher-frequency components of the speech signal.

79. (A) Mels
The perceived pitch of a complex tone is quantified psychoacoustically using the Mel scale. While physical frequency is measured in hertz, the Mel scale is constructed based on human subjective judgments of pitch intervals. It assigns a pitch value of one thousand Mels to a one thousand hertz reference tone played at forty decibels above the hearing threshold.

80. (A) Both A and R are true and R is the correct explanation of A.
Before digitizing an analog speech signal, an anti-aliasing low-pass filter must be applied. This is because any continuous frequency component exceeding the Nyquist rate folds back into the lower frequency spectrum during sampling. This folding causes irreversible aliasing distortion, corrupting the target baseband speech. Thus, the filter is required to remove these high-frequency components.

81. (D) Greater compression for low-level signals
In mu-law companding systems, the compression profile is dictated by the parameter μ. Increasing this value alters the logarithmic compression curve, making it steeper for small inputs. This results in greater compression for low-level signals, assigning them finer quantization resolutions. This non-uniform quantization optimizes the signal-to-noise ratio for typical high-variance human speech.

82. (C) It passes the bitstream through an integrator and a low-pass filter
A delta modulation receiver reconstructs the analog speech signal from a single-bit stream. The received bits, indicating step direction, are fed directly into an analog or digital integrator, which reconstructs the staircase approximation of the waveform. This rough staircase signal is then passed through a low-pass filter to smooth out high-frequency quantization noise.

83. (B) It dynamically adapts its predictor and quantizer step size
Standard DPCM uses a fixed predictor and quantizer step size, which cannot adapt to the non-stationary, highly dynamic characteristics of natural speech. ADPCM overcomes this limitation by dynamically adapting both its predictor coefficients and quantizer step size based on the variance of the prediction error, significantly reducing both slope overload and granular noise distortions.

84. (B) I, II and III
Parametric vocoders achieve very low bitrates by modeling speech parameters, though they compromise natural quality. Waveform coders reconstruct the exact signal shape, preserving phase information. CELP operates as a hybrid coder, utilizing both parametric LPC filters and waveform-matching codebooks to balance quality and bitrate. Linear predictive coding, however, focuses primarily on magnitude rather than phase.

NODIA

85. (A) Spectral leakage (side-lobe amplitude)
Truncating a continuous speech signal with a rectangular window introduces sharp step discontinuities at the frame boundaries. This results in significant spectral leakage, characterized by high-amplitude side lobes in the frequency domain. Applying a tapered Hanning window smoothly attenuates the signal to zero at the frame boundaries, effectively reducing these side-lobe levels and spectral leakage.

86. (A) P-2, Q-3, R-1, S-4
The rectangular window has the narrowest main lobe but exhibits the highest side-lobe levels. The Hamming window features a tapered cosine shape that does not reach zero at its edges. The Hanning window is zero at its boundaries, forming a smooth cosine curve. The Blackman window has a very wide main lobe but extremely low side-lobes.

87. (A) Inverse Fourier Transform
Homomorphic speech processing is used to separate the vocal tract filter from the excitation source. After taking the magnitude spectrum of the windowed speech signal and applying a complex or real logarithm to linearize the multiplicative relationship, the inverse Fourier transform is calculated. This step maps the log-spectrum back into the time-like cepstral domain.

88. (D) Filtering
In cepstral analysis, the signal components are distributed along a quefrency axis. Low-quefrency

regions contain the slowly varying vocal tract envelope, while high-quefrency regions capture the rapid excitation pitch periods. Applying a lifter to select or attenuate specific quefrency ranges is mathematically analogous to applying a filter in the frequency domain.

89. (B) They are uncorrelated, allowing diagonal covariance matrices
During MFCC feature extraction, applying the Discrete Cosine Transform to the log-filter bank energies effectively decorrelates the features. This decorrelation is highly beneficial for pattern recognition systems using Gaussian Mixture Models, as it allows the system to utilize diagonal covariance matrices instead of full ones, drastically reducing the number of parameters to train.

90. (C) It is a flat-spectrum random noise sequence
The standard LPC model represents speech production using a source-filter framework. For unvoiced speech, such as whispers or fricatives, the vocal cords do not vibrate. The fundamental assumption made is that the excitation signal is a random, white noise sequence with a flat spectrum, which is subsequently shaped by the all-pole filter.

91. (D) Toeplitz structure
The Covariance method of solving linear prediction equations minimizes prediction error over a finite, unwindowed interval. This approach yields a symmetric, positive-definite covariance matrix. Unlike the autocorrelation method, which windows the signal to assume it is zero outside the frame, the covariance matrix lacks a Toeplitz structure, meaning its diagonals do not have identical elements.

92. (A) Levinson-Durbin recursion
The partial correlation coefficients, widely known as PARCOR or reflection coefficients, are calculated as intermediate parameters during the execution of the Levinson-Durbin recursion. This efficient recursive algorithm solves the autocorrelation-based Yule-Walker equations, transforming the speech autocorrelation values into LPC predictor coefficients, lattice filter structures, and stable reflection parameters.

93. (B) The radius of the polynomial roots in the z-plane
In LPC formant analysis, the estimated all-pole filter poles correspond to the roots of the predictor polynomial in the complex z-plane. While the angles of these poles represent the formant center frequencies, their radii, or distance from the origin, determine the formant bandwidths. Poles closer to the unit circle yield sharper, narrower formant bandwidths.

94. (B) Words and their phonemic spellings
A lexicon, or pronunciation dictionary, is a critical component of automatic speech recognition systems. It acts as a bridge between the acoustic models and the language model. The lexicon primarily defines the mapping between orthographic words and their corresponding sequences of phonetic symbols, allowing the decoder to translate phonemes into recognized words.

95. (A) Forward algorithm
In Hidden Markov Model frameworks, evaluating the total probability of observing a specific sequence of acoustic features given a model is known as the evaluation problem. This is solved optimally and efficiently using the Forward algorithm. This dynamic programming technique sums the probabilities of all possible state paths that could have generated the observations.

96. (B) I, II and III
Hidden Markov Models are highly effective for speech recognition because they model both spectral and temporal characteristics. The Markov assumption states that the transition to the next state depends only on the current state. Transition probabilities capture temporal sequencing, while emission probabilities model the spectral variations within each state. HMMs inherently preserve this sequential nature.

97. (D) It bandpass filters feature temporal trajectories to suppress steady noise
The RASTA technique is designed to improve speech recognition robustness in noisy and channel-distorted environments. It operates by applying a bandpass filter to the temporal trajectories of the spectral or ceptral features. This filtering process suppresses slow, static channel distortions as well as rapid, non-speech spectral changes, preserving only the modulation rates characteristic of natural speech.

NODIA

118. (C) Spectrally flat (white)
An optimal LPC prediction filter acts as an inverse filter that captures and removes the vocal tract's spectral resonances. When a speech signal is passed through this filter, all the formants are flattened out. Ideally, the resulting prediction error residual has a spectrally flat, white spectrum, containing only the raw excitation source information.

119. (A) The absence of clear word boundaries (coarticulation)
Continuous speech recognition is significantly more complex than isolated word recognition. The primary structural challenge is the complete absence of clear pause boundaries between spoken words, combined with the effects of coarticulation, where adjacent phonetic sounds influence each other. This requires the system to dynamically model overlapping word transitions and segmentations.

120. (D) The accumulated global distance
Dynamic Time Warping compares two time-series patterns that may vary in speed. By building a grid representing the local distances between all frames of the test and reference templates, DTW uses dynamic programming to search for an alignment path. The overall optimal path is found by minimizing the accumulated global distance along the grid.

121. (A) I, II, III and V
GMMs are used to model the multi-modal probability density functions of continuous speech features. The number of mixtures dictates the model's accuracy. Using diagonal covariance matrices is highly efficient since MFCC features are decorrelated. These GMM parameters are trained iteratively alongside the hidden states of the HMM using the Baum-Welch expectation-maximization algorithm.

122. (C) The channel distortion must be linear and time-invariant over time
Cepstral Mean Subtraction is designed to mitigate channel distortions. For CMS to be mathematically effective, the channel distortion must behave as a linear, time-invariant system over the course of the speech utterance. Under this condition, the channel acts as a constant additive offset in the cepstral domain, which is easily canceled by subtraction.

123. (A) Both A and R are true and R is the correct explanation of A.
At low signal-to-noise ratios, spectral subtraction can cause severe degradation of speech quality and intelligibility. This occurs because the noise estimate often fluctuates, requiring heavy overestimation to suppress background noise. This overestimation creates large artificial gaps in the speech spectrum, generating severe musical noise and signal distortion that reduces clarity.

124. (A) Clean speech power spectrum to noisy speech power spectrum
The classic Wiener filter transfer function in the frequency domain is designed to suppress additive noise. It is formulated based on the ratio of the clean speech power spectrum to the total noisy speech power spectrum. This ratio acts as an attenuation factor, passing frequencies with high SNR while suppressing regions dominated by noise.

125. (B) Glottal closure instants (GCIs)
Pitch-synchronous speech processing algorithms segment the speech waveform into frames that are synchronized with the physical pitch cycles. To prevent phase mismatch and audible distortions during pitch or time-scale modification, the system requires highly accurate detection of the glottal closure instants, which serve as the anchor points for window alignment.

126. (A) P-2, Q-1, R-3, S-4
Spectral subtraction operates by manipulating the short-time magnitude spectrum of the noisy signal. Wiener filtering is formulated to achieve minimum mean square error optimization. Comb filtering enhances speech harmonics in the time-frequency domain using delayed pitch-period signals. Cepstral Mean Subtraction is a feature-domain normalization technique used to reduce channel distortion.

127. (A) Odd multiples of the quarter-wavelength frequency
A uniform acoustic tube that is closed at one end and open at the other acts as a quarter-wavelength resonator. The standing waves created within this tube have a node at the open end and an antinode at the closed end. Consequently, the resonant frequencies are proportional to odd multiples of the quarter-wavelength frequency.

Downloaded from www.pdf.tube

108. (A) High sample-to-sample correlation
Speech signals are characterized by a high degree of redundancy, resulting in high correlation between adjacent time-domain samples. The predictor in a DPCM system leverages this sample-to-sample correlation to estimate the value of the upcoming sample. Quantizing only the remaining low-variance prediction error instead of the raw signal yields significant coding gain.

109. (B) An adaptive codebook and a stochastic (fixed) codebook
To achieve high-quality speech reconstruction at very low bitrates, CELP coders represent the excitation source using a two-part hybrid model. It utilizes an adaptive codebook, which captures the long-term pitch periodicity of voiced speech, combined with a stochastic or fixed codebook, which models the remaining high-frequency noise and residual details of the signal.

110. (B) Increased spectral leakage
Applying a rectangular window to segment a continuous speech signal truncates the waveform abruptly at the edges, introducing sharp discontinuities. In the frequency domain, these time-domain step changes manifest as high-amplitude side lobes, causing significant spectral leakage. A Hamming window avoids this by tapering the signal smoothly at the boundaries.

111. (B) I, III and IV
The Short-Time Fourier Transform assumes the signal is stationary within each short analysis window. Because windowing introduces edge truncation artifacts, overlapping frames are used to ensure smooth transition and prevent reconstruction errors. The resolution in both time and frequency domains is strictly bound by the chosen window length, adhering to the uncertainty principle.

112. (C) Glottal closure instants
A wideband spectrogram utilizes a short window in the time domain, which yields high temporal resolution. For voiced speech, this fine temporal resolution is capable of resolving the individual pitch pulses produced by the vocal folds. Each distinct vertical striation visible in the spectrogram represents a glottal closure instant, where a sudden burst of acoustic energy occurs.

113. (D) Addition
In the time domain, speech is modeled as the convolution of the glottal excitation source and the vocal tract filter. Homomorphic processing applies the Fourier transform, followed by a complex logarithm, which converts this convolutional relationship into a simple addition. In the resulting complex cepstrum domain, the source and filter components are linearly additive.

114. (C) DCT compacts most energy into lower-order coefficients
During MFCC feature extraction, the log-energy outputs of adjacent Mel-scale filters are highly correlated. The Discrete Cosine Transform is preferred over the DFT because it exhibits excellent energy compaction properties. It decorrelates the filter bank energies and concentrates the major phonetic information into a few lower-order, real-valued coefficients, which are ideal for acoustic modeling.

115. (A) II, I, III, IV
LPC analysis of a speech signal begins by applying a window function, such as a Hamming window, to the segmented frame. Next, the autocorrelation coefficients of this windowed signal are calculated. The Yule-Walker equations are then solved using the Levinson-Durbin recursion. Finally, the prediction error or residual signal is calculated.

116. (D) It distorts frame edges, modifying the spectral envelope
The autocorrelation method of LPC requires windowing the speech frame to taper the edges to zero, which guarantees a stable estimated filter. However, a primary theoretical disadvantage of this step is that windowing distorts the signal properties near the frame boundaries. This artificial amplitude attenuation alters the true spectral envelope of the speech segment.

117. (A) The reflection coefficient k_m
The Levinson-Durbin algorithm is an iterative procedure that solves the Yule-Walker equations for linear prediction. At each step of the recursion, the algorithm directly computes the reflection coefficient for that order. This reflection coefficient is then utilized to update the predictor coefficients from the previous step, building the filter order incrementally.

NODIA

98. (C) To further reduce the remaining musical noise artifacts
In basic spectral subtraction, underestimating the noise can leave random residual noise peaks, which create a distracting musical noise artifact. Applying an overestimation factor scales up the noise estimate before subtraction. This oversubtraction ensures that the fluctuating peaks of the background noise are completely zeroed out, further reducing the presence of musical noise.

99. (B) By filtering in the STFT domain using short overlapping frames
Speech is a highly dynamic, non-stationary signal over long durations. To apply stationary enhancement models like the Wiener filter, the continuous signal is processed in the short-time Fourier transform domain. By analyzing the speech in short, overlapping frames of twenty to thirty milliseconds, the signal can be considered quasi-stationary, satisfying the mathematical filter design assumptions.

100. (D) A is false but R is true.
Comb filtering relies on detecting and preserving the sharp harmonic structures spaced at integer multiples of the fundamental pitch frequency. While this makes it highly effective for voiced speech, the assertion is false because unvoiced fricatives completely lack a harmonic structure, meaning a comb filter is completely unsuitable for enhancing these noise-like sounds.

101. (A) The closing phase of vocal folds during phonation
During phonation, subglottal air pressure forces the vocal folds open. As air rushes through the narrow glottal constriction, its velocity increases, creating a localized drop in air pressure. This pressure drop, known as the Bernoulli effect, generates a suction force that pulls the vocal folds back together, driving the closing phase of vocal fold vibration.

102. (C) Voice Onset Time (VOT)
Distinguishing between voiced and unvoiced plosives at the beginning of a syllable depends primarily on Voice Onset Time. This acoustic cue measures the temporal interval between the release of the plosive burst and the onset of vocal fold vibration. Unvoiced plosives exhibit a significantly longer delay before voicing begins compared to their voiced counterparts.

103. (A) The filter transfer function
In the source-filter theory of speech production, the vocal tract behaves as an acoustic filter. Moving the tongue, jaw, and lips changes the physical geometry of the oral cavity. This geometrical reorganization alters the resonant frequencies, which mathematically modifies the filter transfer function, shifting the formant positions to produce different vowel sounds.

104. (D) Critical bands
The human auditory system acts as a spectrum analyzer, processing sounds through a series of overlapping bandpass filters on the basilar membrane. The concept of critical bands defines these frequency intervals. Within each critical band, the ear integrates acoustic energy to determine overall perceived loudness and masking thresholds, reflecting the non-linear physiology of hearing.

105. (B) Aliasing
When sampling an analog speech signal, any high-frequency component that exceeds half the sampling rate violates the Nyquist criterion. During digitalization, these high frequencies cannot be properly resolved and fold back into the lower frequency spectrum. This folding causes an irreversible distortion known as aliasing, which corrupts the desired baseband signal.

106. (C) The degree of compression applied to signal amplitude
In digital telecommunication networks, A-law companding is a standard non-uniform quantization scheme. The parameter A determines the exact mathematical shape of the logarithmic compression curve. It dictates the degree of compression applied to the signal amplitude, ensuring that low-amplitude speech segments are quantized with finer resolution, optimizing the dynamic range.

107. (D) The difference between current and predicted samples
Delta Modulation is a simple predictive coding system that uses a one-bit quantizer to represent the speech signal. This single bit does not code the absolute signal amplitude. Instead, it indicates the sign of the difference between the current analog input sample and the accumulated staircase prediction, determining whether to step up or down.

Click Here to Buy book on Amazon

128. (C) Anti-resonances in the spectral transfer function
During the production of nasal consonants, the oral cavity is closed while the velum is lowered, coupling the nasal cavity to the vocal tract. This creates a side branch in the acoustic path. This acoustic branching introduces zeros, or anti-resonances, into the overall spectral transfer function, which absorb acoustic energy at specific frequencies.

129. (D) Non-uniformly spaced auditory bandpass filters
The physiological properties of the basilar membrane in the human cochlea establish a frequency-to-place mapping. This layout behaves conceptually like a bank of non-uniformly spaced bandpass filters. These critical bands are highly narrow at low frequencies and become progressively wider as the center frequency increases, defining the limits of auditory resolution.

130. (B) 6 dB
The signal-to-quantization-noise ratio of a uniform quantizer is theoretically determined by the number of bits used to represent each sample. Mathematically, each additional bit of resolution doubles the number of quantization levels, halving the quantization step size. This step reduction decreases noise power, yielding an approximate increase of six decibels in the SQNR.

131. (B) It reduces slope overload distortion for a given step size
In delta modulation, slope overload distortion occurs when the input signal changes faster than the step size can track. Increasing the sampling rate increases the number of steps taken per unit of time. This higher update rate allows the staircase approximation to climb more rapidly, significantly reducing slope overload distortion for a given step size.

132. (D) Accommodate non-stationarity of speech
Speech is highly non-stationary, with its amplitude variance and spectral properties changing rapidly over time. Standard DPCM uses a fixed predictor and step size, which cannot handle these fluctuations efficiently. The primary objective of ADPCM is to accommodate this non-stationarity by dynamically adjusting both its predictor and quantization step size to track signal variations.

133. (B) I and III
Parametric vocoders achieve extreme data compression by directly modeling the human speech production mechanism. Rather than transmitting the waveform residual, they transmit slow-varying filter and excitation parameters. While this achieves low bitrates, these vocoders lack wave-shape fidelity, resulting in synthetic-sounding speech that is less natural than the output of waveform coders.

NODIA

134. (C) Stationary
Speech is a dynamic, non-stationary signal because the vocal tract continuously changes shape. However, the physical movement of the articulators is relatively slow compared to acoustic waves. Over a sufficiently short time interval of ten to thirty milliseconds, the signal properties can be considered approximately stationary, allowing the use of standard Fourier analysis.

135. (A) Rectangular window
In short-time Fourier transform analysis, different window functions offer different spectral characteristics. The rectangular window applies an abrupt truncation to the time-domain signal. This sudden truncation mathematically yields the narrowest main-lobe width among standard windows. However, this narrow main lobe comes at the expense of high-amplitude side lobes, causing severe spectral leakage.

136. (C) Plosives
Plosives, or stop consonants, are produced by complete obstruction of the vocal tract followed by a sudden release of air pressure. This physiological mechanism manifests on a spectrogram as a silent gap representing the closure phase, which is immediately succeeded by a sudden, intense burst of acoustic energy spanning a broad frequency range.

137. (A) Fourier Transform $\rightarrow$ Complex Logarithm $\rightarrow$ Inverse Fourier Transform
Computing the complex cepstrum of a sequence requires converting convolution in the time domain into addition in the cepstral domain. This is achieved by first computing the Fourier transform of the signal, then taking the complex logarithm of this spectrum to separate magnitude

reducing parameter count and mitigating data sparsity, making statements I and III correct.

197. (A) Spectral Subtraction
Spectral subtraction acts as a prominent feature compensation technique designed to combat additive background noise. It operates by estimating the noise power spectrum during non-speech intervals or silence, and then directly subtracts this estimated spectrum from the magnitude or power spectrum of the active speech frames, enhancing the overall signal quality and intelligibility.

198. (D) Random, isolated dark spots (islands of energy)
Musical noise in spectral subtraction arises from the statistical fluctuations of the short-time noise spectrum. On a spectrogram, these fluctuations manifest as random, short-lived, isolated dark spots or islands of energy. These narrow-band spectral peaks appear and disappear randomly across successive frames, creating an audible and highly distracting musical ringing artifact.

199. (B) Mean Square Error (MSE)
Wiener filtering is a classic linear filtering approach designed for stationary signals. The mathematical objective of the Wiener filter is to produce an estimate of the clean speech signal that minimizes the mean square error, representing the average squared difference between the true clean speech waveform and the filtered, enhanced speech output.

200. (C) Prosody modification (e.g., pitch shifting and time scaling)
Pitch-synchronous processing techniques require operations to be tightly locked to the physical glottal cycles or epochs of voiced speech. This synchronous alignment is highly critical for prosody modification applications, such as pitch shifting and time scaling, as it allows alterations to be made without introducing phase disruption or unnatural speech artifacts.

201. (D) The harmonics of the fundamental frequency
Comb filtering enhances speech quality by matching its frequency response peaks to the periodic harmonic components of the voiced speech signal. This targeted amplification reinforces the fundamental frequency and its integer harmonics, while simultaneously suppressing the broadband noise located in the spectral valleys between these adjacent speech harmonic peaks of speech.

202. (A) The space between the vocal folds
The glottis is anatomically defined as the physical opening or space situated between the vocal folds. During phonation, the vocal folds vibrate, continuously opening and closing this aperture to modulate the outgoing airflow from the lungs, which generates the periodic acoustic pulses that serve as the primary source for voiced speech.

203. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
The fundamental frequency of adult male speakers is statistically lower than that of adult female speakers. This acoustic difference is directly explained by the physiological characteristics of the larynx, as male vocal folds are typically longer and have a larger mass, causing them to vibrate at a slower rate under steady lung pressure.

204. (B) Plosives
The rapid transition of the second formant frequency from the release of a consonant into the succeeding vowel is a crucial acoustic cue in speech perception. This dynamic F2 locus transition indicates the rapid movement of the articulators, serving as the primary cue for identifying the place of articulation of plosives.

205. (A) The lip radiation characteristic
In the acoustic theory of speech production, the final speech spectrum is modeled as a product of three primary systems. The variable source-filter output is shaped by the lip radiation characteristic, which accounts for the high-pass filtering effect occurring as the acoustic pressure wave transitions from the vocal tract into the open atmosphere.

206. (C) Mel-scale Filter Bank
The human auditory system resolves frequencies non-linearly, showing higher resolution at lower frequencies. The Mel-scale filter bank is specifically designed to replicate this biological characteristic by spacing its triangular filters linearly below one thousand hertz and logarithmically above, closely mimicking the critical bands and frequency resolution of the human basilar membrane.

Downloaded from www.pdf.tube

147. (A) Sets all negative spectral estimates to zero
Spectral subtraction algorithms can occasionally yield negative power spectral values due to overestimation or the statistical variance of the noise estimate. Half-wave rectification is applied to resolve this physical impossibility by setting all negative spectral estimates to zero, thereby ensuring that the reconstructed magnitude spectrum remains non-negative and mathematically valid for signal synthesis.

148. (C) Noise suppression and speech distortion
The generalized Wiener filter formulation incorporates a tunable parameter to manage the inherent trade-off in speech enhancement. Adjusting this parameter allows system designers to balance the level of background noise suppression against the level of speech signal distortion, preventing the introduction of unnatural artifacts like musical noise while still improving overall speech quality.

149. (A) III, I, II, IV
Comb filtering enhances speech by leveraging the harmonic structure of voiced sounds. The logical sequence of operations begins with determining if the frame is voiced or unvoiced, estimating the fundamental pitch frequency for voiced frames, constructing a comb filter with resonant peaks aligned with those pitch harmonics, and finally filtering the noisy speech signal.

150. (D) The global masking threshold calculated from speech energy peaks
In psychoacoustics, the audibility of noise in the presence of speech is determined using the global masking threshold. This threshold is calculated dynamically by combining the absolute threshold of hearing with the individual masking curves generated by the tonal and noise-like spectral energy peaks of the speech signal across different critical bands.

151. (B) The tongue
Vowel sounds are acoustically characterized by the continuous flow of voiced air through an unobstructed vocal tract. The tongue acts as the primary active articulator responsible for shaping this tract, as its vertical height, horizontal advancement, and shape alter the cross-sectional area of the oral cavity, thereby determining the primary formant frequencies.

NODIA

152. (B) I and III
Voiced fricatives like /z/ are produced with simultaneous vocal fold vibration and turbulent constriction, containing both a periodic harmonic source and an aperiodic noise source. Conversely, unvoiced sounds are produced without glottal vibration, entirely lacking fundamental frequency harmonics. Plosives are transient and not characterized by continuous harmonic energy, making statements I and III correct.

153. (D) Only the spacing of the harmonic lines changes
According to the source-filter model, the speech spectrum is the product of the excitation source and the vocal tract filter. Aliasing due to undersampling affects the frequency domain representation of the periodic excitation source, causing a folding of the spectrum that directly alters the perceived spacing of the harmonic lines without shifting the vocal tract formant resonances.

154. (A) It aligns with the critical bands of human hearing
The Bark scale is a psychoacoustic scale that models the frequency resolution of the human auditory system. It is designed such that equal distances on the Bark scale correspond directly to the width of the auditory critical bands, which reflect how the basilar membrane in the cochlea processes and resolves overlapping frequency components in speech.

155. (A) 2 kHz
When sampling a signal without an anti-aliasing filter, any frequency component exceeding the Nyquist frequency, which is half of the sampling rate, will fold back into the baseband. For a sampling rate of ten kilohertz, the Nyquist frequency is five kilohertz, causing an eight kilohertz tone to fold back to two kilohertz.

156. (B) It increases
In A-law companding, non-uniform quantization is used to optimize the dynamic range for speech. The logarithmic compression curve results in a quantization step size that increases as the input signal amplitude increases, thereby allocating smaller steps and higher resolution to low-amplitude signals where quantization noise is far more noticeable.

157. (A) $\frac{\Delta}{T_s} < \left| \frac{dm(t)}{dt} \right|$

acoustic energy that is subsequently modulated by the larynx and vocal tract.

177. (B) The resonant frequencies of the vocal tract
Formants are defined as the acoustic resonant frequencies of the vocal tract. When the excitation source passes through the vocal cavity, specific frequencies are amplified depending on the shape and length of the tract, appearing as prominent energy peaks in the spectrum that serve as primary cues for identifying different vowel sounds.

178. (D) I, II and III
The acoustic model of speech production incorporates three fundamental stages. The excitation source represents the physical acoustic energy generated at the glottis or constriction, the vocal tract filter acts as an acoustic resonator shaping the spectral characteristics, and the radiation component models the high-pass filtering effect occurring as sound propagates from the lips.

179. (B) 1050 Hz
Simultaneous auditory masking is most effective when the frequency of the masking tone is extremely close to the frequency of the target signal, particularly within the same critical band. A one thousand hertz tone will therefore most strongly mask a adjacent tone at ten hundred and fifty hertz, as they stimulate overlapping regions on the basilar membrane.

180. (B) 8 kHz
Standard telecommunication networks constrain telephone speech bandwidth to a range between three hundred and thirty-four hundred hertz. According to the Nyquist-Shannon sampling theorem, the minimum sampling rate must exceed twice the highest frequency component, making an eight kilohertz sampling rate the standard choice to prevent aliasing during analog-to-digital conversion processes.

181. (A) P-3, Q-2, R-1, S-4
The parameters of speech quantization map directly to practical acoustic performance. The sampling rate determines the highest unaliased frequency according to Nyquist, the companding law adjusts dynamic range to balance signal-to-quantization-noise ratio, the bit depth dictates the uniform quantization noise floor, and adaptive step sizes are employed to mitigate slope overload and granular noise.

182. (D) Increasing the step size
Slope overload distortion in a delta modulator occurs when the physical rate of change of the input speech signal exceeds the maximum slope tracking rate of the encoder. Increasing the quantization step size allows the reconstructed staircase signal to rise or fall more rapidly per sampling interval, thereby directly alleviating slope overload.

183. (B) Backward adaptation
In Adaptive Differential Pulse Code Modulation, backward adaptation updates the quantizer step size dynamically using only the historical sequence of previously quantized error samples. Because both the encoder and decoder can independently extract this parameter from the transmitted bitstream, no side information regarding the step size needs to be transmitted over the channel.

184. (C) The voiced/unvoiced decision
In parametric speech coders, the voiced or unvoiced decision dictates the selection of the synthesis excitation source. For voiced frames, the synthesizer utilizes a quasi-periodic pulse train generator to mimic vocal fold vibration, whereas for unvoiced frames, it switches to a random noise generator to represent turbulent, non-periodic frication noise excitation.

185. (D) Convolution of the signal spectrum with the window's spectrum
Multiplying a continuous speech signal by a finite windowing function in the time domain corresponds to a mathematical convolution of the signal spectrum with the window's Fourier transform in the frequency domain. This convolution introduces spectral leakage, where the main lobe and side lobes of the window function distort the physical spectral representation.

186. (A) The length (duration) of the analysis window
The duration of the analysis window dictates the fundamental resolution trade-off in the short-time Fourier transform. A longer window yields high frequency resolution but poor temporal tracking of non-stationary events, whereas a shorter window improves time resolution at the expense of frequency resolution, representing the

Click Here to Buy book on Flipkart

167. (B) Line Spectral Frequencies (LSFs)
In speech coding, reflection coefficients are highly sensitive to quantization noise, which can compromise filter stability. Converting these coefficients into Line Spectral Frequencies provides a robust alternative representation, because LSFs possess localized spectral sensitivity, meaning quantization errors in one coefficient only affect a limited frequency band while ensuring filter stability.

168. (C) It models the fine harmonic structure instead of the smooth vocal tract envelope
The predictor order in linear predictive coding determines the maximum number of poles in the vocal tract model. If this order is set too high, the model overfits the speech signal, causing it to resolve the fine harmonic structure of the glottal source rather than extracting the smooth spectral envelope of the vocal tract filter.

169. (D) To evaluate $P(\text{acoustic features} \mid \text{phonetic state})$
The acoustic model in a standard speech recognition system is responsible for bridging the gap between acoustic waveforms and linguistic units. Specifically, it computes the conditional probability of observing a particular set of feature vectors, such as MFCCs, given a candidate phonetic state within the hidden Markov model network structure.

170. (A) The path must be monotonically non-decreasing
In Dynamic Time Warping, constraints are imposed to ensure that the time-alignment path is physically realistic. The monotonicity constraint dictates that the path indices must be non-decreasing in both time axes, preventing the alignment from reversing directions in time and ensuring that the chronological ordering of phonetic events is preserved.

171. (B) MFCC features are approximately uncorrelated, saving immense computational load
Applying a discrete cosine transform during feature extraction decorrelates the filter-bank energies, producing roughly independent coefficients. Consequently, standard Gaussian mixture models can utilize a diagonal covariance matrix instead of a full covariance matrix, which drastically reduces the number of model parameters to estimate and saves immense computational resources during search.

172. (B) II, III, I, IV
Implementing Cepstral Mean Subtraction follows a logical flow to normalize acoustic features. The process begins by computing the cepstral feature vectors for the entire utterance, then calculating the average mean vector of these features over time, followed by subtracting this mean vector from each individual frame, and finally passing the normalized features to the acoustic model.

173. (A) The noise estimate cannot adapt quickly enough, leading to severe artifacts
Basic spectral subtraction assumes that the background noise is highly stationary, estimating the noise spectrum primarily during non-speech activity. In highly non-stationary noise environments, the noise properties change rapidly, meaning the static noise estimate fails to adapt quickly, resulting in severe processing artifacts such as structural speech distortion and residual musical noise.

174. (C) (A) is true but (R) is false.
Wiener filtering is mathematically optimized to minimize the mean square error between the clean speech signal and its estimate under stationary conditions. However, the filter is derived solely from the power spectral densities of the signal and noise, relying on the noisy phase spectrum for time-domain reconstruction rather than estimating or reconstructing the phase itself.

175. (D) The fundamental pitch period
Comb filtering enhances voiced speech by passing the harmonic frequencies while attenuating the inter-harmonic noise regions. To construct the filter peaks accurately, the fundamental pitch period must be estimated with exceptionally high precision, as even minor errors in the pitch period calculation will misalign the filter teeth, causing attenuation of the speech harmonics instead of enhancement.

176. (C) The lungs and respiratory system
The lungs and respiratory system act as the primary power supply for human speech production. Air expelled from the lungs creates a steady aerodynamic subglottal pressure beneath the vocal folds, which initiates and sustains glottal vibration during phonation, supplying the

Downloaded from www.pdf.tube

and phase, and finally applying the inverse Fourier transform to return to the quefrency domain.

138. (A) Phase information
During the extraction of Mel-Frequency Cepstral Coefficients, the speech signal is transformed into the frequency domain using the short-time Fourier transform. The system then discards the phase information by computing the magnitude or power spectrum before applying the Mel-scale filter bank, as human speech perception is primarily sensitive to spectral magnitude rather than short-term phase variations.

139. (B) The predictor coefficients
In the all-pole model of linear predictive coding, the parameter sequence represents the predictor coefficients. These coefficients are optimized to minimize the residual prediction error by linearly combining previous speech samples to estimate the current sample value, thereby capturing the spectral envelope of the vocal tract filter while filtering out the source excitation.

140. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
The autocorrelation method of linear prediction guarantees that the resulting all-pole synthesis filter is stable, which is mathematically equivalent to being a minimum-phase filter. This stability is inherently ensured because the roots of the predictor polynomial derived from this specific formulation are mathematically constrained to lie strictly inside the unit circle of the complex plane.

141. (C) $O(p^2)$
The Yule-Walker equations in the autocorrelation method of linear predictive coding present a Toeplitz matrix structure. While standard matrix inversion algorithms require cubic time complexity, the recursive Levinson-Durbin algorithm leverages this Toeplitz symmetry to systematically compute the predictor coefficients, significantly reducing the overall computational demand to quadratic time complexity of order p squared.

142. (C) LPC models smooth over the spectral peaks if the predictor order is too low
In linear predictive coding, the predictor order determines the maximum number of peaks or formants that the spectral envelope model can represent. If this order is chosen to be too low, the model lacks the necessary degrees of freedom, which causes it to smooth over closely spaced spectral peaks and fail to resolve adjacent formants.

143. (D) The language model probability $P(W)$
In automatic speech recognition, Bayes' Theorem is utilized to find the most likely word sequence given the observed acoustic features. The decoding process combines the acoustic model likelihood, representing the probability of the features given a word sequence, with the language model probability, which represents the prior probability of that specific sequence of words.

144. (C) The computational and template storage requirements grow linearly or faster
Dynamic Time Warping performs pattern matching by aligning a test utterance with stored reference templates. As the vocabulary size expands, the system must perform pairwise comparisons against a larger set of templates, causing the computational load and storage footprint to scale linearly or even quadratically, which limits its applicability to large-scale, continuous recognition tasks.

NODIA

145. (B) P-2, Q-3, R-4, S-1
The fundamental components of speech recognition systems are defined by distinct mathematical expressions. The acoustic model computes emission probabilities, the language model estimates prior word sequence probabilities, the feature extraction process maps raw speech samples to low-dimensional vector representations, and the decoder search determines the optimal word sequence that maximizes the posterior joint probability formulation.

146. (D) Parallel Model Combination (PMC)
Parallel Model Combination provides robust speech recognition in noisy environments by acting directly on the clean speech hidden Markov models. It combines the clean acoustic models with a separate noise model in the linear spectral domain, avoiding the need for front-end feature enhancement and preserving the statistical consistency of the recognition framework under additive noise.

mathematical limitation known as the Weyl-Heisenberg inequality.

187. (C) 20-30 ms
Narrowband spectrograms are designed to resolve individual harmonic lines, which requires high frequency resolution. To achieve this, an analysis window with a longer duration, typically between twenty and thirty milliseconds, is applied, which sufficiently captures multiple pitch periods and provides the narrow filter bandwidth necessary to isolate closely spaced harmonics in frequency.

188. (B) They are multiplicative
In speech production, the acoustic output is modeled as the convolution of the excitation source and the vocal tract filter in the time domain, which corresponds to a multiplicative relationship in the frequency domain. Applying the logarithm transforms this multiplication into addition, enabling linear filtering techniques to separate the two components in the cepstral domain.

189. (A) I, IV, II, III
Extracting Mel-Frequency Cepstral Coefficients follows a precise sequence. First, the continuous speech signal is segmented into overlapping frames and windowed. Next, the fast Fourier transform computes the spectrum of each frame. Triangular Mel-filterbank integration is then applied to warp the frequency scale, and finally, the discrete cosine transform decorrelates the log energies.

190. (C) Predictor order
Linear Predictive Coding approximates each speech sample as a weighted linear combination of a specific number of immediately preceding samples. The parameter defining the count of past samples used in this prediction is the predictor order, which directly dictates the complexity and spectral peak resolution of the resulting all-pole model of the vocal tract.

191. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
The Levinson-Durbin algorithm is used to solve the linear equations produced in the autocorrelation method of linear predictive coding. Because the autocorrelation matrix exhibits a Toeplitz structure, where elements on any diagonal are equal, the algorithm can solve the system recursively with quadratic time complexity rather than requiring expensive standard matrix inversion.

192. (C) Reflection coefficients (k-parameters)
Reflection coefficients, or k-parameters, provide a highly reliable representation of the vocal tract filter in linear predictive coding. A key mathematical property of these coefficients is that the resulting all-pole synthesis filter is guaranteed to remain stable if and only if the absolute magnitude of each reflection coefficient is strictly less than one.

193. (B) The fundamental pitch period
The residual signal of linear predictive coding represents the excitation source after removing the vocal tract formant resonances. For voiced speech, the prominent spikes in this residual correspond to the glottal closure instants, and the time intervals between these successive spikes accurately define the fundamental pitch period of the speaker's phonation.

194. (D) Have different spellings but identical pronunciations
Homophones pose a substantial challenge for automatic speech recognition systems because they share identical phonetic pronunciations despite having different spellings and semantic meanings. Acoustic models alone cannot resolve these ambiguities, requiring the decoder to rely heavily on language model context and syntactic probability to select the correct spelling for the transcribed output.

195. (B) $O(N \times M)$
The standard Dynamic Time Warping algorithm computes a cumulative distance grid between a reference template of length N and a test sequence of length M. Since every cell in the grid must be evaluated sequentially using dynamic programming, the worst-case computational complexity scales proportionally to the product of both lengths, yielding quadratic complexity in standard implementations.

196. (B) I and III
Triphone models in speech recognition incorporate immediate phonetic context to capture coarticulation, making them significantly more accurate than context-independent monophones. Because the number of possible triphones is extremely large, state tying using decision trees is applied to cluster similar acoustic states,

Click Here to Buy book on Amazon

Slope overload distortion in delta modulation occurs when the analog input signal changes too rapidly for the step-by-step approximation to track. Mathematically, this condition is met when the maximum rate of change of the message signal exceeds the maximum tracking capability of the system, defined by the step size divided by the sampling period.

158. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Differential Pulse Code Modulation achieves a higher signal-to-noise ratio than standard Pulse Code Modulation at equivalent bit rates. This improvement is due to the fact that adjacent speech samples are highly correlated, allowing the system to quantize only the prediction error, which has a significantly smaller variance than the original uncompressed speech signal.

159. (D) Random white Gaussian noise sequences
In Code-Excited Linear Prediction coding, the stochastic codebook is typically populated with random white Gaussian noise sequences. This structure represents the unpredictable, non-periodic component of the residual excitation signal, which is filtered through the long-term pitch predictor and short-term LPC filter to reconstruct natural-sounding speech during the analysis-by-synthesis optimization loop.

160. (C) The speech signal cannot be considered stationary over 200 ms
Speech analysis assumes that the signal properties are quasi-stationary over short time intervals, typically between twenty and thirty milliseconds. A frame length of two hundred milliseconds is inappropriate because the physical characteristics of the vocal tract and articulators change dynamically, violating the stationarity assumption necessary for meaningful short-time spectral or linear predictive analysis.

161. (B) It interpolates the spectrum, increasing grid density without improving resolution
Zero-padding a windowed time-domain frame prior to computing the Fourier transform appends zeros to the sequence, which interpolates the resulting spectrum in the frequency domain. This process increases the density of the frequency grid points but does not increase the physical resolution, which is fundamentally limited by the duration of the window.

162. (D) P-4, Q-1, R-2, S-3
Spectrograms display temporal and spectral characteristics of speech. Formant frequencies appear as prominent dark horizontal bands, while glottal pulses produce vertical striations. Silent periods or closure durations are visible as blank white regions, and the aperiodic energy of unvoiced fricatives is represented by high-frequency random dark spots distributed across the spectrogram.

163. (A) Logarithm of the magnitude of the Fourier transform
The real cepstrum of a discrete signal is mathematically defined as the inverse Fourier transform of the natural logarithm of the magnitude of its Fourier transform. This homomorphic deconvolution technique is widely used in speech processing because it successfully separates the source excitation from the vocal tract transfer function in the quefrency domain.

164. (C) They become wider and overlap more at higher frequencies
In computing Mel-Frequency Cepstral Coefficients, the triangular filter bank is designed to mirror human auditory perception, which exhibits lower frequency resolution at higher ranges. Consequently, the filters are spaced linearly at lower frequencies and logarithmically at higher frequencies, meaning they become progressively wider and overlap more as the frequency increases.

165. (A) Infinite Impulse Response (IIR) filter
The all-pole model of the vocal tract represents a system where the output depends on a linear combination of its past outputs and the current input. Mathematically, this recursive feedback structure is equivalent to an Infinite Impulse Response digital filter, which is capable of generating the resonant spectral peaks or formants characteristic of speech.

166. (A) I, II and IV
Comparing linear predictive coding formulations reveals distinct characteristics. The covariance method does not apply a window function to taper the speech frame, and its resulting system matrix is non-Toeplitz. Conversely, the autocorrelation method assumes the signal is zero outside the frame boundaries and always guarantees the stability of the estimated synthesis filter.

NODIA

207. (B) 4 kHz
The Nyquist-Shannon sampling theorem establishes that to prevent aliasing during the digitization of a continuous signal, the sampling rate must be strictly greater than twice the highest frequency component. Therefore, if a signal is sampled at eight kilohertz, the maximum unaliased frequency that can be represented is exactly four kilohertz.

208. (C) 64 kbps
In standard digital telecommunication systems, a single voice channel is digitized using standard Pulse Code Modulation. By sampling the signal at eight kilohertz to satisfy Nyquist for standard telephone bandwidth and using eight bits per sample to represent compressed amplitudes, the transmission rate is calculated as exactly sixty-four kilobits per second.

209. (B) By transmitting an alternating sequence of 1s and 0s
Delta modulation encodes an analog signal by tracking its slope with a single-bit output. When the input signal is a constant DC level, the slope is zero, causing the modulator to oscillate continuously around the target amplitude, which results in transmitting an alternating sequence of ones and zeros representing granular noise feedback.

210. (D) Difference between the sample and its prediction
Differential Pulse Code Modulation is designed to reduce the transmission bit rate of digitized speech by leveraging sample correlation. Instead of quantizing the raw amplitude of each sample directly, the system quantizes only the prediction error, which represents the mathematical difference between the current input sample and its predicted value estimate.

211. (A) Emphasize errors in the formant valleys where noise is more audible
Code-Excited Linear Prediction incorporates a perceptual weighting filter during the analysis-by-synthesis search. Because the human ear is less sensitive to noise in high-energy formant peaks due to masking, the filter emphasizes quantization errors in the low-energy formant valleys where noise is much more audible, optimizing the subjective quality of synthesized speech.

212. (C) P-1, Q-3, R-4, S-2
The windows and filters in speech processing serve distinct purposes. A rectangular window introduces high spectral leakage due to sharp boundaries, while a Hamming window reduces this leakage through tapered edges. Overlapping frames prevent data loss caused by this tapering, and pre-emphasis filtering boosts high-frequency components to compensate for spectral tilt.

213. (A) Better time resolution, poorer frequency resolution
In the short-time Fourier transform, reducing the analysis window length shortens the temporal integration interval, allowing the system to track rapid signal transitions more accurately. However, this reduction limits the frequency resolution because a shorter window contains fewer samples, broadening the main lobe of the window function in the spectral domain.

214. (D) Poor frequency resolution and high time resolution
Wideband spectrograms are computed using a very short analysis window, typically between three and five milliseconds. This short temporal duration yields exceptionally high time resolution, allowing the visualization of individual glottal pulses, but results in poor frequency resolution, making it impossible to resolve individual narrow harmonic lines in the spectrum.

215. (B) Continuous and unwrapped
Computing the complex cepstrum requires applying the complex logarithm to the spectrum of the signal. To prevent mathematical discontinuities, the phase spectrum must be continuous and unwrapped, meaning the discontinuous phase modulo two-pi wraps are resolved to reconstruct a smooth, continuous phase function across all evaluated frequency bins systematically.

216. (C) Critical band energy integration
The filter bank integration step in Mel-Frequency Cepstral Coefficients extraction replicates the critical band processing of human hearing. By grouping and summing the spectral energy within overlapping triangular band-pass filters, the model simulates how the auditory nerve integrates acoustic energy within specific frequency bands along the length of the basilar membrane.

Downloaded from www.pdf.tube

217. (D) Nasal consonants
The standard linear predictive coding framework uses an all-pole transfer function to model the vocal tract filter. This assumption struggles with nasal consonants because the oral cavity is closed while the nasal tract is open, creating side branches that introduce zeros (anti-resonances) into the spectrum, which cannot be efficiently modeled by poles.

218. (A) All elements on any given diagonal are identical
In the autocorrelation formulation of linear prediction, the system of equations is represented by a Toeplitz matrix. The defining mathematical property of a Toeplitz matrix is diagonal constant symmetry, meaning that all elements situated along any given diagonal are identical, which enables highly efficient recursive solutions systematically.

219. (A) I and II
The Levinson-Durbin algorithm is designed to solve the Yule-Walker equations generated specifically by the autocorrelation method, rather than the covariance method. It functions iteratively by computing the predictor coefficients from order one up to p, requiring the systematic calculation of reflection coefficients at each recursive step, making statements I and II correct.

220. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Formant frequencies can be directly estimated by computing the roots of the LPC predictor polynomial. This is because the roots of the polynomial are mathematically equivalent to the poles of the recursive vocal tract transfer function, representing the resonant frequencies where the vocal tract filter amplifies specific acoustic energy components.

221. (A) The immediately preceding word
Language models in speech recognition utilize statistical history to constrain search paths. A bi-gram model is a first-order Markov process that estimates the conditional probability of the current word occurring based solely on the identity of the immediately preceding word, ignoring earlier linguistic history to simplify parameter estimation requirements.

NODIA

222. (C) Endpoint constraint
In Dynamic Time Warping, boundary conditions are enforced to ensure a complete alignment between the signals. The endpoint constraint mandates that the optimal warping path must begin exactly at the first frames of both sequences and terminate precisely at the final frames of both sequences, preventing partial or incomplete alignments during search.

223. (D) Training the emission and transition probabilities
The Baum-Welch algorithm is a specialized expectation-maximization algorithm used in speech recognition. Its primary function is to train the parameters of a hidden Markov model, including the state transition and emission probability distributions, by iteratively maximizing the likelihood of the training speech data given the model topology structure.

224. (C) It high-pass filters the temporal trajectory of cepstral coefficients
Cepstral Mean Subtraction normalizes speech features by subtracting the average cepstral vector calculated over an entire utterance. Mathematically, this subtraction acts as a high-pass filter applied directly to the temporal trajectory of each cepstral coefficient, effectively removing the zero-frequency DC component that represents stationary convolutional channel distortion.

225. (B) The a posteriori Signal-to-Noise Ratio (SNR) of the current frame
In spectral subtraction, the oversubtraction factor controls the amount of estimated noise subtracted from the noisy spectrum. To minimize speech distortion while suppressing noise, this factor is dynamically adjusted on a frame-by-frame basis using the calculated a posteriori signal-to-noise ratio, applying more subtraction in low-SNR frames.

226. (D) Zero
In the mathematical derivation of the Wiener filter, clean speech and background noise are assumed to be statistically independent processes with zero-mean distributions. Consequently, the cross-correlation between the clean speech signal and the noise is theoretically assumed to be exactly zero, simplifying the formulation of the optimal filter transfer function.

227. (A) Modifying the pitch and duration of speech
Pitch-synchronous overlap-and-add is a widely utilized speech processing technique in speech synthesis. It enables high-quality prosody modification by separating the speech signal into overlapping short-time segments synchronized with the glottal epochs, allowing the pitch and duration of the speech to be modified independently and cleanly.

228. (B) 40 samples
To design a comb filter that aligns its resonant peaks with the speech harmonics, the delay length must equal the fundamental pitch period in samples. For a fundamental frequency of two hundred hertz and a sampling rate of eight kilohertz, the pitch period is calculated as eight thousand divided by two hundred, which is exactly forty samples.

229. (A) Nyquist-Shannon Sampling Theorem
The Nyquist-Shannon sampling theorem establishes the conditions for error-free digitization and reconstruction of continuous signals. It dictates that if a signal contains no frequencies higher than B hertz, it can be perfectly reconstructed from its discrete samples by applying ideal low-pass interpolation, which mathematically corresponds to filtering with a sinc function.

230. (D) P-4, Q-1, R-2, S-3
Distinct phonetic classes exhibit unique acoustic characteristics. The F2 locus transition indicates the place of articulation in stops, while the burst frequency marks the plosive release. Nasal consonants are characterized by anti-resonances or zeros in their complex spectrum, and unvoiced fricatives feature high-frequency, continuous, noise-like acoustic energy in their spectrum.

231. (B) Lower average formant frequencies than female voices
Formant frequencies are determined by the physical length of the vocal tract, acting as an acoustic tube closed at one end. Because the average adult male vocal tract is significantly longer than that of females, the resonant wavelengths are longer, directly resulting in lower average formant frequencies for male voices.

232. (B) I, II and III
A continuous speech signal possesses several fundamental properties. It is non-stationary over long durations, but contains short segments of quasi-periodicity corresponding to voiced speech, and aperiodic noise-like segments corresponding to unvoiced speech. Its energy distribution is non-uniform, concentrated heavily in the lower frequencies, making statements I, II and III completely correct.

233. (D) Equal-Loudness contours
Human perception of loudness is highly non-linear and varies as a function of frequency. Equal-Loudness contours, such as the Fletcher-Munson curves, describe the physical sound pressure level required for tones at different frequencies to be perceived as equally loud as a reference tone at one kilohertz frequency.

234. (A) It reduces the required precision of the anti-aliasing filter
Sampling a signal at a rate significantly higher than the Nyquist rate, known as oversampling, increases the frequency gap between the desired baseband signal and its high-frequency aliasing images. This wide transition band dramatically reduces the required precision and slope steepness of the analog anti-aliasing filter, allowing simpler filter designs.

235. (B) Very large, providing high gain
In mu-law companding, the compression characteristic is logarithmic. When the input signal amplitude is small, the slope of the logarithmic compression curve is extremely steep, which means the compander provides a very large amplification, ensuring high resolution and small quantization steps for low-level signals where noise is most perceptually critical.

236. (B) During silent or relatively constant amplitude intervals
Granular noise in delta modulation occurs when the input signal remains relatively flat or changes very slowly. Because the coder's step size is fixed, the reconstructed staircase signal is forced to continuously oscillate above and below the true signal level during constant amplitude intervals, producing a steady high-frequency background granular noise.

237. (A) The signal variance to the prediction error variance
The prediction gain of a Differential Pulse Code Modulation system acts as a standard metric of predictor performance. It is mathematically

Click Here to Buy book on Flipkart

PAPERGPT
125, Sector 6, Vidhyadhar Nagar, Jaipur 302039

MRP. ₹ 650

ASRB EXAM 2026

ELECTRONICS & INSTRUMENTATION

Scan QR For Demo PDF

NODIA

complex conjugate root pairs that are positioned close to the boundary of the unit circle.

248. (D) 64000
A triphone represents a phoneme in the context of its immediate left and right neighbors. For a language containing forty distinct phoneme units, the total number of logically possible triphone combinations is calculated by raising the phoneme count to the third power, which equals exactly sixty-four thousand possible triphones overall.

249. (D) Dynamic programming search to find the most likely state sequence
During the decoding stage of an automatic speech recognition system, the Viterbi algorithm is applied to identify the optimal state alignment. It utilizes dynamic programming to efficiently search through the hidden Markov model state network, identifying the single most likely path of hidden states that maximizes the joint posterior probability formulation.

250. (A) Maximum Likelihood (ML)
The expectation-maximization algorithm, also known as the Baum-Welch algorithm in speech recognition, is utilized to estimate the parameters of hidden Markov models. The mathematical criterion minimized or maximized during this iterative optimization process is the maximum likelihood of the observed acoustic data given the model parameters.

251. (B) The log spectral or cepstral coefficients
RelAtive SpecTrAl filtering is designed to suppress slow-varying convolutional channel noise in speech recognition. It achieves this by applying a band-pass filter directly to the temporal trajectories of the log spectral or cepstral coefficients, effectively removing both static channel components and rapid, non-speech frame-to-frame fluctuations systematically.

252. (A) I and II
Spectral subtraction assumes that noise is additive and statistically uncorrelated with the clean speech signal. The algorithm requires an accurate estimate of the noise power spectrum, typically updated during silent frames, and operates solely on the magnitude or power spectrum without modifying the phase, making statements I and II strictly correct overall.

253. (A) Statistical variance in noise estimates leading to unsubtracted spectral peaks
The generation of musical noise in spectral subtraction is primarily caused by the statistical variance inherent in short-time noise spectrum estimation. This variance leads to random, unsubtracted spectral peaks after subtraction, which appear as short-duration, isolated sinusoidal-like tones that fluctuate randomly across successive frames of the enhanced signal spectrum.

254. (C) Power spectrum of the clean speech
In the standard formulation of the Wiener filter for speech enhancement, the filter gain is determined by the power spectral densities of the signals. The numerator term specifically represents the power spectrum of the clean, uncorrupted speech signal, which is estimated from the noisy observations using statistical approximation techniques systematically.

NODIA

255. (D) The instant of sudden glottal closure
In pitch-synchronous speech analysis, an epoch represents a critical timing event within the glottal cycle of voiced speech. Physically, this epoch corresponds to the instant of sudden glottal closure, which produces a highly significant acoustic excitation pulse that can be detected as a prominent peak in the speech residual signal.

256. (C) The delay length must be halved
The delay length of a comb filter must equal the fundamental pitch period in samples to align the filter peaks with the speech harmonics. If the fundamental frequency of the speaker doubles, the physical pitch period is halved, meaning the required delay length in samples must also be halved accordingly.

257. (B) Voicing
The phonemes /s/ and /z/ share the identical alveolar place of articulation and fricative manner of articulation. The sole articulatory feature that distinguishes them is voicing, as the production of /z/ involves active vocal fold vibration (voiced), whereas /s/ is produced without glottal vibration (unvoiced) conditions.

258. (B) -12 dB/octave
In the source-filter model, the glottal volume velocity waveform represents the excitation source for voiced speech. Due to the gradual opening and rapid closing of the glottis during

phonation, this glottal source waveform exhibits a low-pass spectral roll-off of approximately negative twelve decibels per octave in the frequency domain representation.

259. (A) Within the same critical band
Simultaneous auditory masking is most pronounced when the masking signal and the target signal are positioned extremely close in frequency. Specifically, masking is maximized when both signals fall within the same critical band of human hearing, as they compete to stimulate the identical localized region of the basilar membrane structure.

260. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Feature extraction techniques for speech recognition, such as MFCCs, typically discard the phase spectrum. This design choice is justified because the human auditory system is largely insensitive to the absolute phase of speech signals, focusing instead on spectral magnitude envelopes to identify phonemes and linguistic structures systematically.

261. (A) Overload distortion (clipping)
In analog-to-digital converters, the clipping threshold represents the maximum input signal amplitude that the quantizer can represent. If the incoming analog speech wave exceeds this threshold, the converter cannot represent the peak values, resulting in severe amplitude clipping and the introduction of high-frequency harmonic overload distortion.

262. (D) A first-order predictor using the previously reconstructed sample value
Delta modulation is a simple predictive coding scheme that quantizes the difference between the current sample and its prediction. It operates as a first-order predictor because it utilizes only the single, immediately preceding reconstructed sample value to predict the amplitude of the incoming analog speech sample value.

263. (B) Zero
Differential Pulse Code Modulation works by predicting the value of the next speech sample and quantizing only the prediction error. In a theoretical scenario where the predictor is mathematically perfect, the predicted value would equal the actual sample value, reducing the variance of the prediction error to exactly zero.

264. (C) Only the previously quantized error values
In Adaptive Differential Pulse Code Modulation, backward adaptation updates the step size of the quantizer using the history of previous outputs. This adaptation relies exclusively on the previously quantized error values, ensuring that both the transmitter and receiver can reconstruct the identical step size without transmitting extra side information.

265. (D) To remove the fine harmonic structure from the residual
In a Code-Excited Linear Prediction coder, the pitch filter acts as a long-term predictor. Its primary role is to model the long-term periodicities of voiced speech, effectively removing the fine harmonic structure from the residual signal before it is modeled by the stochastic codebook and short-term LPC filter components.

266. (A) About 10 ms (resulting in 50-67% overlap)
Frame blocking splits continuous speech into short frames to perform quasi-stationary analysis. To ensure smooth transitions between successive frames and prevent loss of information at the window edges due to tapering, a frame shift of approximately ten milliseconds is utilized, introducing a fifty to sixty-seven percent overlap systematically.

267. (B) Convolving it with the window's Fourier Transform
Multiplying a continuous speech signal by a window function in the time domain corresponds to a mathematical operation in the frequency domain. Specifically, the Fourier transform of the windowed speech frame is obtained by convolving the signal's infinite Fourier transform with the calculated Fourier transform of the windowing function itself.

268. (A) I and II
Spectrograms provide rich visual cues of speech characteristics. Formants appear as prominent dark horizontal bands in wideband spectrograms, while narrowband spectrograms display horizontal striations that allow tracking of individual harmonics and pitch. Unvoiced fricatives concentrate energy at high frequencies,

Downloaded from www.pdf.tube

not below five hundred hertz, making statements I and II correct.

269. (A) Only the low-quefrency components
In homomorphic speech processing, liftering is applied in the cepstral domain to separate speech components. Because the vocal tract spectral envelope varies slowly with frequency, its information is concentrated at low-quefrency indices, requiring the lifter to retain only the low-quefrency components to isolate the smoothed spectral envelope.

270. (C) It transforms multiplicative components into additive ones
In computing Mel-Frequency Cepstral Coefficients, the logarithm function is applied to the filter-bank energies. This step is pivotal because speech is modeled as the convolution of the excitation source and vocal tract filter, which is multiplicative in the frequency domain. The logarithm transforms these multiplicative components into additive ones, allowing linear separation.

****

NODIA

defined as the ratio of the original speech signal variance to the variance of the prediction error signal, quantifying the signal power reduction achieved by exploiting sample-to-sample correlation properties.

238. (C) Model of the vocal tract to test excitation vectors
In Code-Excited Linear Prediction, the encoder utilizes an analysis-by-synthesis loop. This structure implies that the encoder contains an internal model of the vocal tract filter. By passing candidate excitation vectors through this synthesis filter, the encoder can select the optimal codebook vector that minimizes the perceptually weighted error difference.

239. (C) 0.95
Pre-emphasis is applied to speech signals to boost high-frequency components, compensating for the natural spectral tilt of human speech. A first-order finite impulse response filter of the form H of z is used, where the parameter alpha represents the filter coefficient, typically chosen close to one, such as exactly ninety-five hundredths.

240. (A) Both (A) and (R) are true and (R) is the correct explanation of (A).
Computing Mel-Frequency Cepstral Coefficients involves applying the Discrete Cosine Transform to the logarithmic filter-bank energies. This step is crucial because the energies in adjacent triangular filters are highly correlated. The transform acts to decorrelate these values, projecting them onto orthogonal basis functions and producing independent coefficients for acoustic modeling processes.

241. (B) Multiplied by a small non-zero value (approx. 0.08)
Applying a Hamming window to a speech frame smooths the signal transition at the frame edges to mitigate spectral leakage. Unlike a Hann window, which tapers exactly to zero, the Hamming window formula yields a small non-zero coefficient, approximately eight-hundredths, at the exact start and end boundaries of the analysis frame.

242. (B) 100 Hz
Narrowband spectrograms are characterized by high frequency resolution, allowing the visualization of individual spectral harmonics. Since the harmonic components of a periodic voice source occur at integer multiples of the fundamental frequency, a speaker with a fundamental frequency of one hundred hertz will exhibit horizontal harmonic lines spaced exactly one hundred hertz apart.

243. (A) It is zero for all negative quefrencies
A minimum-phase signal has all of its poles and zeros located strictly inside the unit circle of the complex plane. This unique mathematical property ensures that the complex cepstrum of the signal is causal, meaning that all cepstral coefficients at negative quefrency indices are identically equal to zero systematically.

244. (C) A quasi-periodic glottal pulse train
Under the source-filter theory of speech production, voiced vowels are synthesized by driving the vocal tract filter with a periodic excitation source. This input signal is modeled as a quasi-periodic glottal pulse train, which represents the rapid opening and closing of the vocal folds during phonation, generating the speech harmonics systematically.

245. (A) A finite, unwindowed interval of the speech signal
In the covariance method of linear predictive coding, the total squared prediction error is minimized over a finite, unwindowed interval of the speech signal. Because the analysis frame is not multiplied by a tapering window, the method avoids window-edge distortion but cannot guarantee the mathematical stability of the resulting synthesis filter.

246. (D) $R(k) = R(-k)$
The Levinson-Durbin recursion relies on the symmetric properties of the autocorrelation sequence. Because the autocorrelation function of a real-valued discrete signal is mathematically symmetric, the autocorrelation sequence satisfies the condition that R of k is equal to R of negative k, enabling the formation of a Toeplitz matrix structure.

247. (B) Complex conjugate roots lying close to the unit circle
In linear predictive coding analysis, formants are represented by the resonant poles of the vocal tract transfer function. When the roots of the predictor polynomial are plotted on the complex z-plane, these resonances are indicated by

Click Here to Buy book on Amazon